

# CEREAL CHEMISTRY

Vol. III

July, 1926

No. 4

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## THE PROBLEM OF TEST BAKES, WITH A DISCUSSION OF CERTAIN OF THEIR CHEMICAL AND PHYSICAL ASPECTS

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(Read at the Convention, June 8, 1926)

As one studies the literature of cereal chemistry, especially that part of it which deals with wheat and wheat flour, he cannot but be impressed with the great importance of test bakes. A reading of that most excellent book by C. H. Bailey, "The Chemistry of Wheat Flour", will illustrate this fact admirably. Test bakes have often been an end in themselves, as in the numerous studies of flour quality which have been published. They have been used to substantiate scientific findings, as, for example, the use Sharp and Gortner made of them (1923) in connection with their viscosimetric studies. Their value in the study of the effect of H-ion concentration in flour is well known (Jessen-Hansen, 1911). They have been used in many other different ways, each with some particular scientific end in view, or some more directly practical end. It is, perhaps, the practical type which has constituted the call for the greatest number of test bakes that have been made. Thousands of these practical test bakes for determining flour quality are made each year.

Whatever is said about all other methods which have been advanced or used in the past, or which have been suggested within recent times, the fact remains that *at present* the one test of flour quality is the test bake. Just as "The proof of the pudding is in the eating," so here we must paraphrase this old adage to read, "The proof of the flour is in the baking."

It has been said above that the test bake gives convincing proof of flour quality. This should, however, be looked into a little further. This much is certain, that test bakes possess their full value as yardsticks for measuring flour quality only when they show optimum results. This does not need to be argued, it is a self-

evident fact. Yet, as axiomatic as it seems, little stress has been laid on it, despite its being so vital.

In my judgment, the solving of the problem of making proper test bakes so that each gives the optimum baking result, is by far the most important single problem confronting cereal chemists today. That the Association of Cereal Chemists considers it of great importance, is attested by the formation of a committee on test bakes. That the problem is a very difficult one, all will admit; but it is, potentially, of such great importance that all the time and energy necessary for its solution are thoroly justifiable.

So far as I am aware, no article has ever appeared in any of our journals on what might be called "simultaneous bakes"; nor has such work been done, except certain experimental work in which I, personally, had a hand. By "simultaneous bakes" I mean two or more operators working side by side, using identical ingredients and conditions of operation, so far as these are physically possible. The work from which I wish to draw an important conclusion was carried out at the Bureau of Chemistry in Washington. There were three operators, L. H. Bailey, Raymond Hertwig, and the writer. The Bureau is splendidly equipped for such work, especially as it is provided with several Bachman mixers which can all be operated as a unit.

In these experiments, the three operators used identical formulas and ingredients in preparing the dough batches. The mixers were all started at the same time, the water and shortening were added at the identical instant, and the extent of the mixing was absolutely uniform. All fermentations were carried out in the same cabinet and at the same time and for the same period. All punches were synchronous and the working or punching of the dough was uniform, that is, the doughs were worked or punched with the hand 40 times after the first rise and 30 times after the second. The doughs went to the same proofing cabinet and at the same time. In fact, uniformity, so far as was humanly possible, prevailed throughout. When the bakes came from the oven, the results were very illuminating, for despite the care taken, they were far from uniform.

These simultaneous bakes were made several times, using different flours and different formulas, as well as different fermentation and punch periods; but, again, the results lacked the uniformity hoped for. There is but one answer to this and that is the human element as it affected the punching of the doughs and the moulding of the loaf in panning. Here we have the first of the



big problems to solve in connection with our test bakes, how to manipulate the dough manually in a uniform manner, so as to get optimum results. Many times I have made simultaneous bakes with Mr. Bergman, in the laboratory of the Industrial Appliance Company. In this laboratory we have but one mixer—a Hobart—but apart from that, conditions were as nearly identical as possible. The doughs had to be prepared at different times, i. e., a few minutes apart. The Hobart mixer, as we use it, is self-limiting as to the time in which a dough is submitted to a mixing action. I consider the Hobart an ideal mixer for this reason. There is no chance to "punish" the gluten. The Hobart mixer in use at the Industrial Appliance Company's laboratory, has a specially constructed hook for the mixing. It is shaped from a single piece of metal rod to match the periphery of the mixing element which accompanies the machine. It has the great advantage that when the water is added to the flour to prepare the dough, the latter, when well mixed, clings to the hook and revolves as a unit with it. If too much water has been used and the dough is too slack, the dough refuses to cling to the hook, but a pinch of dry flour thrown into the bowl will remedy this difficulty.

At the Industrial Appliance Company's laboratory, in practically every instance, Mr. Bergman's results are greatly superior to mine. Here, again, it is the skill in handling the dough that gives him superior results. From this, however, have resulted certain facts and conclusions to which reference will be made later.

This phase of the subject need not be discussed further, except again to emphasize the point that the manual handling of dough—the human element—is one of the very important factors of the test bake problem. Everything else being equal, a test bake may be made or marred by the way the dough is punched and the loaf moulded.

Certain phases of this test bake problem have occupied my attention for many months. The results presented are simply a few of those obtained many times. They emphasize in no uncertain manner (1) the effect of H-ion concentration on the fermentation period; and (2) that as fine a loaf of bread cannot be produced from fresh flour, however it is fermented, as is obtainable from the same flour if its pH is lowered and the fermentation period properly shortened.

I have voiced this opinion before, but not publicly as now, and I have had men whose opinion I value highly, differ from me. This much can be said, however, I have never been able to get as

fine results from fresh flours as from the same flours with a lower pH, however the former were handled from a fermentation standpoint. Furthermore, I am inclined to the view that when fresh flour does give as good results, the operator is manually punishing his doughs with the lower pH. But more of this later.

I wish to give you one set of baking experiments made with a Kansas hard wheat 97% flour, having a pH range of 6.12 in the fresh flour to 5.29 when matured with 2 ounces of Beta Chloral per barrel. The titratable acidity varied from 0.139% to 0.216% and, from the figures in Table I, it may be seen that each ounce of Beta Chloral per barrel increases the titratable acidity by approximately 0.040%, for Matured I was treated with  $\frac{1}{2}$  ounce per barrel and II, III, and IV were stepped up by increasing increments of  $\frac{1}{2}$  ounce per barrel each.

TABLE I

	pH	Acidity %	1st Exp.	2nd Exp.	3rd Exp.	Pan Min.	Total Min.	Vol. cc.	Color %	Texture %	Value %
Fresh	6.12	0.139	80	40	30	65	215	2160	100	100	100.0
Matured I	5.90	.158	70	35	30	63	198	2250	103	102	103.0
Matured II	5.69	.178	60	30	30	66	186	2300	104	103	104.5
Matured III	5.48	.198	50	30	30	63	173	2400	105	104	106.7
Matured IV	5.29	0.216	45	25	20	63	153	2520	106	105	109.2

The flour had an ash of 0.44% and a protein content of 10.45%. The baking formula was as follows:

Flour	380 grams
Yeast	10 "
Salt	5 "
Sugar	11 "
Shortening	9 "
Water	220 cc.

The fermentation and proofing were both at 86°F., the oven temperature 440°F., and the length of baking approximately 35 minutes.

Table I is akin to one found on page 222 of Bailey's "Chemistry of Wheat Flour" but is a little more in detail, but without the Linter values. The work was done in April, 1924, as a unit piece of work, but a few days subsequent to bakes made with the same flours as reported in Table II.

If we combine Tables I and II, and separate each flour according to its pH, we can get a clearer view of the point I wish to make about fermentation periods and H-ion concentration. This has been done in Table III.

TABLE II

	pH	Acidity %	Expansion			Pan Min.	Total Min.	Vol. cc.	Color %	Texture %	Value %
			1st Min.	2nd Min.	3rd Min.						
Fresh	6.12	0.139	110	55	30	79	274	2040	100	100	100.0
Matured I	5.90	.158	110	55	30	74	269	2050	103	102	101.7
Matured II	5.69	.178	110	55	30	73	268	2050	104.5	103	102.5
Matured III	5.48	.198	110	55	30	71	266	2150	105	104	104.8
Matured IV	5.29	.216	110	55	30	66	261	2100	106	105	104.6
Fresh	6.12	.139	90	45	30	75	240	2190	101	101	103.1
Matured I	5.90	.158	90	45	30	70	235	2300	103	103	106.2
Matured II	5.69	.178	90	45	30	65	230	2240	105	104	106.3
Matured III	5.48	.198	90	45	30	63	228	2130	105	104.5	104.6
Matured IV	5.29	.216	90	45	30	58	223	2120	106	105.5	105.1
Fresh	6.12	.139	60	30	30	61	181	2130	101	102	102.4
Matured I	5.90	.158	60	30	30	61	181	2250	103	104	105.8
Matured II	5.69	.178	60	30	30	62	182	2380	104	105	108.5
Matured III	5.48	.198	60	30	30	59	179	2340	105	105	108.2
Matured IV	5.29	0.216	60	30	30	57	177	2340	106	105	108.6

In Table III, the effect of a varying pH on the total fermentation period, as reflected in the volume, is clearly evident. The fresh flour, as well as that matured with  $\frac{1}{2}$  ounce of Beta Chlora per barrel, has reached the peak of its bread-producing qualities. This may or may not be true of the other treated flours, for they were still producing bread of increasing volume and yet, if the fermentation periods were still further shortened, they, too, may have produced results showing that they had reached their optimum. Nothing but the volume produced by the bakes has been included in Table III, but I think you will agree with the statement that, as the volume increases, there is also an increase in those qualities which go to enhance bread value, such as texture and color. These points are given in Tables I and II.

TABLE III

	pH	Total Min.	Volume cc.
Fresh	6.12	274	2040
"	6.12	240	2190
"	6.12	215	2160
"	6.12	181	2130
Matured I	5.90	269	2050
"	5.90	235	2300
"	5.90	198	2250
"	5.90	181	2250
Matured II	5.69	268	2050
"	5.69	230	2240
"	5.69	186	2300
"	5.69	182	2380
Matured III	5.48	266	2150
"	5.48	228	2130
"	5.48	179	2340
"	5.48	173	2400
Matured IV	5.29	261	2100
"	5.29	223	2120
"	5.29	177	2340
"	5.29	153	2520



From the data so far presented, certain deductions are to be drawn. These deductions are not to be based wholly and solely on these figures, in connection with the data of a similar character found in Bailey's book, to which reference has been made. As previously indicated, similar results have been obtained many times, and with all types of flours. Conclusions are as follows:

- 1 There is an increase in titratable acidity, with a consequent lowering of pH, when flour is treated with Beta Chloral, which consists of 99.5% chlorine and 0.5% of nitrosyl chloride.
- 2 The optimum bread results, as the pH is lowered, are obtainable only with a considerably shortened fermentation period.
- 3 The flours with the lower initial pH, produce, with a shorter fermentation, a bread quality unobtainable with a fresh flour.
- 4 To determine the baking or bread value of flours, each must be handled in accordance with its nature. If this is not done, no accurate measure of flour quality is possible.

These sets of bakes made with five samples of flour, were for the purpose of illustrating the important part that H-ion concentration plays in the bread production of any flour, and the modification and periods of fermentation of the dough. Flours which had been matured by the Perfect Flour Maturing System were used, as this treatment offered a method for progressively increasing in the H-ion concentration.

You may question whether or not the enhanced baking qualities of a matured flour are due to the increase in the H-ion concentration. So far as now known, there are no other basic factors to which these results are to be attributed; and we must recognize the fact that the increase in H-ion concentration of a dough by deliberate acidification with acids *per se* does produce results similar to those which have been discussed above. We know, further, that the increase in H-ion concentration due to the treatment of a flour with Beta Chloral, increases the Lintner value. This has also been shown by Rumsey (1922), who altered the pH of flours by the direct addition of acids. Whatever value accrues in baking, to the increase in the activity of the diastase through increase in the H-ion concentration, is doubtless due to the fact that there is, through this increase, a nearer approach to the optimum pH for the functioning diastase. I am inclined to the view that there are

other and possibly more important changes taking place, due to this decreased pH, and it is this problem that I wish to bring to your attention.

Before doing so, mention should be made of a novel result which has come out of our baking experience, which may prove of considerable interest to you. It is the custom to divide the punch periods so that there is a long fermentation period first, followed by a shorter one. We have found that when the doughs have a high initial hydrogen-ion concentration or induced acidity, the baking results are much better if this procedure is reversed, that is, if the short period is first, followed by the longer one. This has been done many times, so often, in fact, that it cannot longer be considered as mere accident. A few examples will illustrate this point. The results are shown in Table IV.

TABLE IV

		Acidity	Ash %	Protein %	Water cc.	Expansion				Pan Min.	Total Vol. Min. cc.	Color %	Tex. %	Val. %
						1st	2nd	3rd						
Hard Wheat	I	0.135	0.42	10.61	224	80	40	30	70	220	2210	100	100	100
"	" I	.135	.42	10.61	224	40	80	30	65	215	2380	101	102	103.5
"	" II	.221	.41	11.33	224	50	30	30	65	175	2400	100	100	100
"	" II	.221	.41	11.33	224	30	50	30	63	173	2510	101	101	102.2
"	" III	.198	.47	14.04	247	70	35	30	56	191	2250	104	102	103.4
"	" III	0.198	0.47	14.04	247	35	70	30	58	193	2400	104	104	106.5

The color and texture in hard wheat flour III are rated over 100% because this rating came from a comparison of simultaneous bakes with the fresh and untreated flours, which were rated at 100% for purposes of comparison.

In all these samples, the acidity was increased by use of Beta Chloral. While Table IV refers to results obtained with hard wheat flours, similar results are found with both spring and soft winter wheats. This method of dividing the punch periods with the shorter one first is now employed in the baking laboratory of the Industrial Appliance Company, in keeping with our contention that in testing the bread value of any flour, it should be so handled as to produce the best loaf of bread of which it is capable.

#### Theoretical Discussion

As wheat flour dough undergoes fermentation in the process of bread-making, certain well-recognized changes take place. These changes are considered to be associated in some way with the gluten and the process is called "conditioning" or "ripening." We say that the gluten has become softened, or pliable and elastic, and such changes seem to be necessary before a dough can produce a satisfactory loaf of bread.

This process of conditioning is a fundamental phenomenon and is a matter of every-day experience with doughs. Yet, despite our familiarity with its results, we have not been able to define clearly those changes in gluten on which it rests. A vast amount of work has been done on gluten and the gluten constituents, gliadin and glutenin, and I have been greatly impressed with some of the work that has been published and its applicability to this problem. Out of it has come a definite viewpoint for the cause underlying this phenomenon. At least, the importance of certain recognized phenomena should be stressed as being, at bottom, the reason why gluten conditions.

It is quite generally accepted that flour quality or strength is dependent, in a large degree, on its gluten. As the pH of a flour or dough is decreased, we have increasing difficulty in washing out the gluten, and it may be impossible to gather it at all.

TABLE V

Hours of fermentation	pH	Dispersed protein based on proteins in flour, %
1	5.77	14.28
3	5.68	16.66
5	5.51	18.50
7	5.24	45.28
9	4.83	72.54
11	4.33	78.86
21	3.92	79.68

A most significant piece of work was published by Johnson and Bailey (1924). On page 377 of their article, these authors discuss the "Effects of hydrogen-ion concentration on dispersion of flour proteins." The significant part of their work lies in the tremendous effect of changing H-ion concentration on the degree of dispersion, as shown by the total protein in the aqueous extracts of fermented doughs, over a range a little above pH5 to a little below it. Their data are given in Tables V and VI.

TABLE VI

Hours of fermentation	pH	Dispersed protein based on proteins in flour, %
0	5.95	15.14
2	.....	17.70
4	.....	20.60
6	5.49	31.76
8	5.12	77.22
10	4.60	87.42
12	4.26	89.52
16	3.92	92.14
18.5	3.86	93.70



From these tables it can be seen that at a pH5 we have 70-80% of the proteins in the disperse phase. In the experiment in question, Johnson and Bailey worked with a soft wheat flour having a total protein content of 9.35%. The doughs on which they experimented were, in ingredients, identical with those normal to bread doughs except for the absence of salt. Their results would have been modified in a degree, doubtless, had salt been present. I do not believe the difference in the degree of dispersion would have been of large magnitude, for we know how difficult it is, if not impossible, to wash out the gluten from a normally constituted bread dough with a low pH—that is, the type that gives us optimum baking results. Hence, we must have in such normal bread doughs, a degree of gluten dispersion of considerable magnitude.

Referring briefly to the well-known work of Jessen-Hansen (1911), you are all familiar with his general findings, namely, that the optimum pH for bread making is about 5, a little higher for choice flours and a little lower for those of lesser quality. It may not be amiss to digress here for a moment in order to point out that this optimum pH idea of Jessen-Hansen has been frequently misinterpreted, as is evidenced by statements in the literature. His optimum pH figures were determined on the doughs as freshly prepared and not on the doughs as ready for the oven, after fermentation had further decreased the pH.

Jessen-Hansen has pointed out the difficulty in washing out the gluten from doughs with a pH corresponding to those giving optimum baking results. It is a fair assumption that the gluten was in a very highly dispersed state, and the degree of dispersion we may perhaps gather somewhat roughly from the quantitative figures of Johnson and Bailey.

That the H-ion concentration of the dough at the time of baking is one of the vital factors in getting optimum results, is no longer doubted. Jessen-Hansen, in his experiments, kept his fermentation period a constant at  $1\frac{1}{2}$  hours, altho his proofing period undoubtedly varied somewhat. He left it to his baker to judge when his proofed dough was ready for the oven. Yet his total period of fermentation, plus the proof period, probably did not vary to any great degree. So we may say that in his work we have results based on a varying pH, but with the time period, roughly at least, a constant.

In the work presented in this paper, there is not only a varying pH, but varying time periods as well. It is regretted that it was not practicable to follow the pH changes through to the point

when the doughs went to the oven. This work should by all means be done with varying types of flours, doughs of varying consistencies as well as of size and weight, including varying dough temperatures, etc.

In what way is further work of the character suggested of value in connection with this problem of gluten conditioning? Our first problem lies with the determination of the optimum pH and optimum fermentation periods of various types of flours. This should be followed by work on the degree to which the gluten has been dispersed under these optimum conditions. Then we shall be in a position to answer our problem properly. As it appears to me, conditioning is a function of the gluten dispersion in the dough and this, in turn, is dependent on the hydrogen-ion concentration.

We are all familiar with the tough and stubborn gluten of spring wheat flours. How often does the bread from such flours show a characteristic thick-walled, non-elastic cellular structure. Yet, if the fermentation is proper and especially if the initial hydrogen-ion concentration is low enough at the outset, we get a splendid oven spring, and a resultant bread in which the cell walls are as thin as the thinnest tissue paper and which possess the sheen of silk. These are phenomena accompanying the lower pH ranges and the shorter fermentation periods. Dispersed gluten must have physical properties quite apart from the undispersed and it is quite believable, in the face of our certain knowledge that dispersion is great in doughs giving optimum baking results, that this very phenomenon of great dispersion is the important factor in the process of gluten conditioning.

Let us picture to ourselves what may be happening in a fermenting dough. The gluten forms a net-like mass, strand connected to strand, with the starch and other ingredients interspersed around and about this gluten net work. These strands must vary considerably in their physical dimensions. As the H-ion concentration increases, the outer layers of these gluten strands become dispersed. These dispersed gluten particles cannot move far; the dough is too viscous. Punching or kneading the dough renders it more homogeneous and exposes fresh gluten surfaces to the further dispersing action of the acids already present or produced by further fermentation. Finally, we reach the stage when the gluten, as such, remains in relatively small amounts and is, for that reason, more easily stretched and elastic. It is just the difference between a heavy rubber band and a slighter one of similar

quality; the latter yields and stretches more easily to the force applied, which in the case of a dough is, of course, the pressure exerted by the  $\text{CO}_2$ .

Earlier in this paper, reference was made to the superior results which Mr. Bergman obtained, when we were carrying on simultaneous bakes. Thinking over our comparative results, especially in the light of this idea of dispersed gluten, the conclusion was reached that the undispersed and tender gluten was being punished too much in all the kneading processes, and especially in the later stages of fermentation, in which the undispersed gluten must be present in delicate strands or ribbons, and as a delicate net work. Punishment of the dough at this stage must rupture this delicate net work and possibly intersperse the starch and other dough ingredients between the broken strands or ribbons, thus preventing their recalescing and destroying the continuity of the gluten frame work beyond repair. Putting this idea to the test and handling the doughs with a degree of gentleness previously unknown in my method of operation, results were produced incomparably better than anything previously obtained. It does not need further exposition to grasp the thought that overworking or punishing the gluten would lead to what one might call "leaky doughs" and hence to reduced bread volume and character. This same result comes equally when the punishment to the gluten is in the mixing machine.

This brings us to a consideration of mixers and their effect on bread quality. Swanson and Working (1926) have recently published an interesting article on this subject. Their idea of the mechanical modification of gluten by the "pack-squeeze-pull-tear" action of their especially constructed dough mixer, is a reasonable explanation of the better results obtained with only the fermentation in the pan. Undoubtedly, mechanical action can and does attenuate the gluten strands to form a fibrous net work, wherein "the attenuated strands are weak enough to allow easy expansion and yet strong enough to retain enough gas to form porous dough." Natural flours, freshly milled, never possess a considerable H-ion concentration, and this would not be markedly augmented merely by fermenting in the pan. Hence, we would expect a rather small degree of gluten dispersion in dough prepared for the oven under the operating condition as set forth by Swanson and Working. The bread quality produced by their methods must be, in great part, dependent on the attenuated gluten strands, which gluten represents the major part of the total gluten, as such,



present in the dough. If the view is tenable, that the dispersion of a large amount of the gluten through a largely increased H-ion concentration is necessary for optimum bread results, then we may expect that better piled loaves will be produced by Swanson and Working's method, if the initial pH of the flour or dough is lower than that found in freshly milled flour and the dough made from it. They carried out one set of experiments, using lactic acid. They state that "the results indicate an advantage in the use of lactic acid as shown by the slight improvement of loaf volume and texture."

In the Southwestern Miller of May 18, 1926, Dr. Swanson elucidates this matter from a little different angle. In discussing a flour-maturing outfit for treating experimental samples of flour with Beta Chloral, he says: "This equipment has proved of particular value, especially since we began to use the method of mechanical modification of dough in testing flour strength from different wheats. When baking flours that have recently been milled, it was found that the pound loaves from treated samples averaged about 300 cc. greater volume and scored higher in texture than the untreated samples. The Beta Chloral has some profound action on the gluten which makes it yield more readily to mechanical modification of dough. By means of this apparatus, flour from different kinds and types of wheat is given the same treatment accorded to flour in commercial milling. Thus, the tests assume a greater practical value."

That Beta Chloral has this "profound action" on gluten for bettering the baking quality of a flour, I have seen exemplified hundreds of times, but not in connection with Swanson's new mixing device. My conviction is strong that the results are due to the production of hydrochloric acid in the flour and the resultant increase in the H-ion concentration. I feel confident that if two doughs are prepared, one of which has been made from flour treated with Beta Chloral, the other with hydrochloric acid *per se*, so that both doughs have the same initial pH, comparable baking results will be produced. At present, I can go only this far—nothing is known to the contrary.

Weaver and Goldtrap (1922) have published an extremely valuable piece of fundamental cereal research. One of their observations is pertinent to our problems. They say that "certain proteolytic enzymes used in the dough batch will condition gluten before the optimum pH is reached." Proteolytic enzymes degrade gluten with the production of soluble products and, with suitable

enzymes, this degradation may be carried as far as the amino acids. Is not this result of Weaver and Goldtrap quite parallel to that obtained through gluten dispersion? The proteolytic enzymes reduce the quantity of gluten as such, so that there will remain that minimal yet optimum amount necessary to give the proper elasticity, expansibility, and gas-retaining properties to the dough. The end is the same as that obtained by depressing the pH, but the means are due wholly to a biochemical process rather than a physico-chemical one. We know that excessive proteolytic activity in a dough produces bad results (Ford and Guthrie, 1908; Sharp and Gortner, 1924). This we may consider as being due to the destruction of altogether too much of the gluten. Excessive fermentation, with the consequent excessive dispersion, likewise produces bad results. It may be that, in some degree, in certain types of flours, there is a joint action of the proteolytic ferments and the dispersing action of acids, with the latter largely predominating.

There is still another viewpoint which should be mentioned. The disperse phase of gluten is in a colloidal condition. Under certain conditions of temperature and concentration, these disperse phases of proteins often assume a gel form, having characteristic properties of elasticity, more or less highly developed. Gels may be formed with as little as 0.5% of the dispersed colloid, in 99.5% of water. Whether this dispersed phase of gluten in dough exists as a gel, we do not know. Certainly, it is there in sufficient concentration to exist as such, judging from concentrations necessary to produce gels in other dispersed colloids. The view might be taken that it is dispersed gluten *per se* and possibly in a gel form, rather than the undispersed, which is the essential factor in baking results and in conditioning a fermenting dough. To this might be added that the fact that the dispersed gluten is in a gel form would not necessarily militate against the ease with which it melts away, as it were, when an attempt is made to gather the gluten through the washing-out process. Such gels are known, altho the phenomenon is not common to all of them. There is, theoretically, still the third possibility, namely, that conditioning is due to a combined action of the dispersed and undispersed gluten, the undispersed forming the net work and the dispersed, in a gel form, making a film over the net work of the undispersed. It must be left to future cereal research to determine the actual facts. In any event, the basic phenomenon accompanying gluten conditioning rests on the development of the requisite hydrogen-ion concentration in the dough. The idea that the dispersion

of gluten is a function of the hydrogen-ion concentration is not new. My thought has been to stress its fundamental importance in the conditioning of gluten.

### Conclusions

1. Regardless of all that the chemist has done through analysis, research, or devices, the test bake, properly made, remains the only way of determining the actual quality of flour. The test bake, to evaluate any flour accurately, must be made in accordance with the character of the flour and in such a manner as to produce the best loaf of which such flour is capable.

2. Experimental bakes made with natural flours with any method of working and fermenting of doughs, do not produce as well-piled loaves, as the same flours with a lower initial pH and shorter fermentation periods.

3. When a flour yields its best baking results, the gluten is soft, pliable, and evenly distributed through the mass, when the dough is put into the oven.

4. Flours with lower initial pH values give better baking results with the first two periods of fermentation of the dough reversed; that is, by having the shorter period first.

5. The conditioning of gluten in doughs is a function of the hydrogen-ion concentration and depends on the phenomenon of gluten dispersion.

### Acknowledgements

I wish to express my appreciation of the work done by Mr. Bergman, of the Industrial Appliance Company, who conducted the baking work discussed in this paper.

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## THE PROBLEM OF STANDARDIZING THE EXPERIMENTAL BAKING TEST

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(Read at the Convention June 8, 1926)

Most cereal chemists agree that the final, if not the only test by which the baking quality of a flour may be satisfactorily judged is the experimental baking test. For the purposes of this paper it will be assumed that such is the case.

The distressing lack of agreement as to the proper method for conducting experimental baking tests is, however, too well known to require the slightest comment. We are frequently reminded of the fact that our most important flour test is the least standardized. The reason is perfectly obvious to all who have given the matter the slightest consideration. The chief difficulty arises from the fact that the test involves too many factors which cannot be satisfactorily controlled. Prominent among these are variations in yeast, in water absorption, and in the "personal equation" which plays an important part in handling the dough. There are other reasons, as this discussion will attempt to point out.

We have all been impressed with the astonishing range and variety of tastes, prejudices, and inclinations manifested by cereal chemists in their respective methods of experimental baking. This condition of affairs, alone, warns us that a **unanimous** endorsement of any single method is an ideal which we can hardly hope to attain, for it is no easy matter to convince the average chemist that he should abandon a practice which has met his special requirements in a fairly satisfactory manner.

It is almost needless to say, however, that the development of a method which would meet with the approval of even a **bare majority** of cereal chemists would be a goal well worth attaining, and a vast improvement over present conditions. Even this achievement will require much time and labor, and a large volume of carefully planned co-operative experimental work.

One of the chief difficulties in the selection of tentative or trial methods has been a failure, first of all, to arrive at a common agreement with regard to the exact object of the test. What information should the standard test be expected to furnish? We must arrive at a common understanding on this point. Without doubt most of us will agree that the primary object of the test, as it is usually performed, is to indicate quality of the flour. But,

unfortunately, the term "flour quality" is subject to a variety of interpretations, and it will be futile to attempt any standard baking methods until this situation has been satisfactorily disposed of.

The main purpose of this paper is to focus attention upon several different interpretations of the term "baking quality," in the hope of emphasizing the contention of the writer that before we begin to work on various formulas, we must first have a fairly uniform and definite idea of the information which the test may be expected to furnish.

First of all there is the question of whether or not there is general agreement upon a definite distinction between the terms "baking quality" and "baking strength." Should we not at the outset decide upon the exact meaning to be attached to each of these expressions, or are we to use them synonymously? The writer's viewpoint on this is that the term "baking quality" refers to the **inherent possibilities** of a given flour, whereas "strength" should mean quality together with ability more or less successfully to withstand a certain amount of variation in handling. Thus a certain soft wheat flour may have excellent quality, that is, it will produce a pleasing and palatable loaf, providing it is carefully and properly handled, but it may at the same time be a "weak" flour, incapable of giving good results when subjected to mechanical punishment or to any slight deviation from a very definite and fixed fermentation period. Thus, a flour may have quality without strength, but not strength without quality. It will be noted that this interpretation would involve a slight modification of Humphries' generally accepted definition of baking strength, which is that "a strong wheat is one which yields a flour capable of making large, well-piled loaves," by adding "under average commercial conditions." However, regardless of the acceptance or rejection of this interpretation, the fact remains that some specific definitions and interpretations must be discussed and agreed upon at once, and such an agreement must precede any serious attempts to standardize the baking test.

Having agreed upon definitions of terms, the next step should be to ascertain what sort of information the majority of cereal chemists can reasonably expect a standard baking procedure to furnish. We know that there is a wide divergence of opinion on this point, even among the most reputable cereal chemists, and it is essential that we carefully listen to, and impartially judge the arguments which may be advanced with respect to any or all of them. As an outcome of this action we may hope to arrive merely



at a satisfactory basis for the selection of a standard procedure, realizing that altho this is merely a beginning, it is a very necessary step.

What are the important points of present disagreement among cereal chemists with regard to the chief purpose of an experimental baking procedure? Perhaps the matter may be simplified by considering only what appear to be the two extremes, other views usually consisting of a mixture of both. One standpoint is that the test should aim to bring out the best loaf that a given flour is capable of producing. The other is that the test should indicate the ability or lack of ability of a given flour successfully to withstand such variations of treatment and handling that one may reasonably expect to find in commercial bake shops. Adopting merely for temporary convenience the definitions of the terms "quality" and "strength" which have been suggested in this paper, it is seen that the first point of view is to ascertain the actual inherent "quality" of the flour, while the second aims more especially at the "strength" idea. Other points of view are generally intermediate, and involve various combinations of the two extremes.

Let us consider the idea that the test should indicate the maximum results which a given flour is capable of producing. There is but one objection to this idea, and that is the utter impossibility of carrying it out. In the first place, there is no ideal loaf of bread, any more than there is an ideal type of cheese. Individual tastes differ, and some folks prefer Limburger cheese to Camembert. It is therefore impossible to set standards for an ideal loaf. Even if this were possible, who could say with definite assurance that a given loaf approached the ideal as closely as the flour would permit? We also know that no two cereal chemists working under identical conditions of formula, temperature, and fermentation period will be likely to bake identical loaves from the same flour. There may be differences of several hundred cubic centimeters in volume, with corresponding differences in texture and flavor. The personal touch of the operator in "knocking down" and molding the dough is the principal cause of these variations. Both operators may have equal experience, training, intelligence, and industry. The fact is that experimental baking of this kind is more of an art than a science. We can no more expect chemists to have equal proficiency in this art than to have the same musical talent and ability. This is the sort of thing that must be eliminated from any standard scientific test, so far as it is possible to do so. Let us assume, however, that the majority of cereal chemists are capable

of attaining the same degree of proficiency in this type of experimental baking, which they are not. How about the commercial bakers? Can we expect them to be able to accomplish with machinery on a large scale what we cannot do by hand on a small scale, and under carefully controlled conditions? For these fundamental reasons, the writer believes that altho there may and doubtless will be frequent occasions which will justify an operator in attempting to produce what he considers to be the optimum results which a given flour is capable of producing, this practice has no place in a present-day practical standard experimental baking procedure.

There are two reasons why the writer inclines toward the notion that the standard experimental baking procedure should aim to indicate "strength" (as previously defined) rather than "quality" alone. One is a conviction that the average commercial baker wants flour which will not only produce results under his own system of operation, but will do so consistently and without the necessity of frequent variations in manipulation. This, in many instances, means a flour which will "stand up" under rather severe mechanical treatment, or slight variations in the fermentation period. The other reason is that as we increase the severity of mechanical treatment in our experimental baking test we will not only more nearly approach the commercial baker's viewpoint, but we will also be tending toward the elimination of the personal element or the "artistic touch" which all will agree must be eliminated so far as possible from any method which makes any pretense of being designated as a "standard method."

The foregoing discussion should not be interpreted as attempting to show that any one single test can be made to serve as a satisfactory standard procedure. The intention is merely to indicate the necessity of reaching an agreement regarding the avenue of approach, in other words, a basis upon which the procedure must be founded; as well as to state the personal views of the writer upon this important matter. An effort has been made to show that the viewpoint of attempting to produce optimum results in our standard procedure should be entirely dismissed from our minds, for it is impractical, and involves the personal equation to the highest degree.

Confining our attention for a moment to the other aspect, it is found that emphasis is placed upon two main points. One is that the average commercial baker wants strength and uniformity, and the other is that it is only in testing for these factors that we

can most nearly approach the elimination of the personal element in our procedure. The necessity of this latter step appears to the writer to be so obvious that it should require no further comment. There then remains only the matter of making the test conform to the desires of the commercial baker. This point will require deliberation and discussion. The first question is "Should we aim at a standard procedure of this character"? The next question is, "What is an average commercial baker"? It appears to the writer that the answer to the first question is "Yes," on the assumption that it is from the commercial bakers that mills get most of their important complaints. Defining the "average commercial baker," however, may appear to be somewhat difficult. Altho we know that commercial bakers vary greatly in such qualities as intelligence, training, resourcefulness, fair-mindedness, etc., we must assume that the average is at least fair-minded and reasonable. A further consideration is the extent to which the average miller is able, even with the aid of a chemist, to produce and maintain **uniformity** of product. This is a highly important matter for the chemists to judge, in arriving at a basis for standard procedure. Do the majority of cereal chemists feel that their respective mills are capable of making a product of sufficient uniformity so that one single baking test will most nearly meet the requirements of a standard procedure, or do the majority feel that their product varies to such an extent that the standard procedure should involve several bakes, in which either the fermentation period or the nature of the mechanical treatment or both is varied? We must always bear in mind, however, that the test must be as simple as possible, for the average industrial chemist is a fairly busy individual, and too many details and complications will cause the procedure to fail utterly from lack of use.

There is no point in developing a standard experimental baking procedure if it is not to be used. Aside from all previous argument, most of us will agree that if the standard procedure is to be used, several requirements will have to be met. In the first place, it must tell us what we primarily want to know concerning the properties of the flour. It must be reasonably simple, and one which may be performed satisfactorily by all cereal chemists of average ability. The personal equation must be reduced to the lowest possible minimum, for if such is not the case it surely will not be standard, since it will give different results in the hands of different workers. This will mean, of course, that mechanical devices will have to be used for operations which are done chiefly by



hand, such as molding, knocking down, etc. It will also mean that even the minutest details must be carefully prescribed and religiously followed. If these conclusions are acceptable, then the entire proposition is reduced to two problems.

1. What constitutes a "reasonably simple" procedure?
2. Can the personal element be reduced to negligible proportion? and how?

If these two problems cannot be solved, under present circumstances, then we may as well for the present give up the idea of developing a standard procedure and confine ourselves strictly to an effort to standardize the formula, the temperature, and the dimensions of the jars and pans. This alone will be a distinct and noteworthy advancement, and well worth the effort. If we confine our efforts to this, however, we must not pretend to call the resulting method a "standard" method, but must restrict ourselves to the use of the term "official," or "approved"; or an expression which conveys a similar meaning. It may be found desirable to develop several "approved methods," each for a special purpose. Under this scheme one procedure might be a series of bakes to ascertain the effect of various mechanical treatments. Another might be a series in which the fermentation period is varied. These and other possibilities are well worthy of consideration.

### Summary

1. Cereal chemists should reach a common agreement with regard to the exact meaning of the terms "baking quality" and "baking strength."

2. A standard experimental baking test should not be attempted until there is a general agreement upon the exact nature of the information which such a test should be expected to furnish.

3. A clear understanding must be had of all that should be implied in the term "standard," as applied to an experimental baking procedure. The writer's ideas of the requirements of a successful standard experimental baking procedure are briefly: It must give the desired information; it must be simple, and yet every detail must be religiously prescribed and followed; it must eliminate the personal element; last, but not least, it must be a method which will be used.

4. If these requirements cannot be met, effort should be restricted to the establishment of an "official" or "approved" method in which only the formula, the temperatures, and the dimensions

of jars and pans are standardized. It may be advantageous to develop several "official" or "approved" methods, each for a special purpose.

These points must be definitely understood, and disposed of before any committee can hope to act in a manner which will satisfactorily interpret the wishes of the body which it represents.

## OXYGEN-ACETATE METHOD OF ASH DETERMINATION IN FLOUR

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(Read at the Convention June 11, 1926)

The necessity for a fast and accurate method of determining ash in flour in the laboratory controlled mills has been desired for a long time. The nearest approach to it was the old calcium-acetate method, which was not highly satisfactory for consistently accurate results. However, calcium acetate has furnished the foundation and starting point for the oxygen-acetate method which we are pleased to offer for your criticism and approval.

The original idea was to adopt the calcium acetate process and try to standardize it so that it could be applied successfully to our regular routine work. This task was given to our research department and nearly three months were consumed in the effort, only to result in failure. Platinum crucibles were supplied to carry on this work. It was after this failure that the writer took up the work, assisted later by Mr. Shirk.

The effort was continued to stabilize the calcium-acetate method and to lower the period of time required to run an ash determination to about one hour. Several solutions of calcium acetate of varying strengths were used in varying quantities of 2 cc. to 5 cc. to each determination. We finally found that a solution of calcium acetate whose strength was approximately N/4.2 proved most satisfactory, using 2 cc. of this solution to a 3-gram charge of flour. It was puzzling at first how best to apply the calcium-acetate solution to the weighed charge of flour. Several ideas were utilized, one of which was to make a paste of the flour by stirring the acetate solution into the flour in the platinum crucibles. The stirring rod was then cleansed by using a piece of ashless filter paper, which was then placed in the crucibles with the flour paste. This mixture was allowed to dry thoroly on the open muffle door

<sup>1</sup>With the assistance of H. L. Shirk.

before placing it in the furnace chamber, which at this time was carried at approximately 1600°F. This procedure did not prove satisfactory, and consumed two hours to burn out the ash. It was quite a problem to provide a sufficient current of air through the muffle to promote proper combustion. Leaving the furnace door slightly ajar was tried, but it allowed the muffle to cool too much. While observing the condition of the ash one day, the effect on the charred mass was noted of bringing it out of the oven into the air. This led to adopting a "breathing period" every five minutes for each determination.

Realizing that to make a flour paste with the acetate solution was considerable trouble, and was clumsy in application, the idea of charring the flour in the muffle was found to be more satisfactory. The acetate solution was then added to the cinder while it was yet quite warm. Placing the crucible on the muffle door, the cinder was allowed to dry thoroly before entering the chamber of the furnace. At this point it was decided to carry the oven temperature at 2000°F. and to continue the five-minute "breathing period" as before. This procedure made it possible to burn out the ash in fifty minutes, but the method was tiresome, strenuous, and required too much attention. Furthermore, a discouraging feature appeared, as the platinum crucibles that we were using began to crystalize and became brittle. They began to crack and chip off around the top. Because of this, vitresol crucibles were substituted. These could not stand the extreme heat, and after being used three or four days, began to scale off, changing weight during the burning of the ash. A good type of porcelain crucible was substituted and proved satisfactory. Several explanations have been offered relative to the crystalization of the platinum crucibles, among which was the formation of platinum carbide. It was also suggested that the phosphate in the flour ash caused this condition, but we discredit this theory. Another idea was that the tongs caused the trouble. We are frank to confess that we have no real explanation to offer.

So far, the method had given us a reasonably fast and accurate procedure, but it proved discouraging because it demanded too much attention by the chemist. The platinum crucibles which we had been using were sent to the manufacturer and exchanged for a slightly smaller type, altho they were yet of the high form. The original crucibles were of 20 cc. capacity, high type. In order to relieve any possibility of the tongs causing trouble, special tongs were ordered, tipped with platinum "boots."



Not being satisfied with the progress made up to this point, the writer decided to attempt the use of oxygen in conjunction with the calcium acetate. A fully equipped cylinder of oxygen was obtained (including pressure gauges) and an oxygen-acetylene torch was also supplied. This torch serves as the agent through which the oxygen is delivered into the muffle chamber. After the first use of oxygen, it was concluded that a much lower temperature could be used and that great care must be exercised in finding the right pressure of the oxygen current to be used. A five-pound pressure, as registered on the gauge, with the air valve wide open on the torch and the oxygen valve set at one quarter turn, proved disastrous. The ash "came down" immediately, flattened out, and was at the point of fusion. A lower pressure of oxygen current was then used, and the muffle temperature reduced to 1700°F. using a pyrometer control in the muffle. The procedure at this juncture consisted of the charring of the flour to a cinder, addition of the acetate solution (2 cc. N/4.2) to cinder while yet quite warm, and drying thoroly on the muffle door. A blank determination was always made, using 2 cc. of the acetate solution and proper correction made for CaO. After drying, crucibles were placed in the muffle and treated with oxygen.

The data in Table I resulted from the first use of oxygen, and it is plain to see how remarkably close the results compare to those from our regular method, which consists of a five-hour burning period at 1100°F, using pyrometer control. It will also be noted that the period of burning by the oxygen-acetate method averaged only  $\pm 28$  minutes. The ash was very light and fluffy, while the platinum crucibles remained bright, with no indication of the tendency to crystallize that was previously experienced.

TABLE I  
DATA SHOWING FIRST USE OF OXYGEN GAS

Sample	Flour charge	N/4.2 Calcium acetate solution	ASH		Character of ash	Pressure of oxygen	Time of burning	Muffle tem- perature
			5 hours regular	Oxygen acetate				
	grm.	cc.	Per ct.	Per ct.		lbs.	Min.	Deg. F.
A	3	2	0.443	0.436	Light Fluffy White	$\frac{3}{4}$ -1	30	1700
B	3	2	.406	.396	" " "	$\frac{1}{2}$	30	1700
C	3	2	.470	.473	" " "	1	28	1700
D	3	2	0.443	0.443	" " "	1	23	1700

Further work was continued with the use of oxygen and the results were most encouraging. The process has been developed to a most reliable procedure which is fast, accurate, and simple. The method finally adopted is as follows:

A 3-gram charge of the sample to be ashed is weighed up in a platinum or porcelain crucible (low form most desirable) and allowed to char into a cinder in the muffle. Removing the crucibles after burning contents to a cinder, 2 cc. of a calcium-acetate solution, the strength of which is approximately N/4.2, is pipetted into crucible, completely wetting the cinder while yet quite warm. Allow acetate solution to evaporate by placing crucibles on opened muffle door. When cinder is completely dried, place crucibles in muffle, the temperature of which is carried at practically 1500°F. After the samples have been in the furnace 3 to 4 minutes, oxygen is delivered into muffle for a period of 10 to 15 minutes. The length of time that the oxygen is sent into the furnace depends largely upon the number of samples, temperature used, and pressure of the oxygen current. The time required for ashing a sample or samples can be regulated to meet the chemist's convenience. A blank determination is made, using 2 cc. of the calcium-acetate solution, and correction made for CaO after evaporating and incinerating. The blank is first dried in a moisture oven and then placed in muffle after oxygen has been removed, and allowed to burn for about 3 minutes. When the "glow" around the bottom of the crucible disappears, it is an indication that the ash is "down." Calcium oxide is used for desiccation. As ash takes up moisture very rapidly, fast and accurate balance work is essential to the successful application of this method.

The data which follow have been taken from our regular work with the foregoing method. Porcelain crucibles of the low form, of 10 cc. capacity, were used and apparently stood the test satisfactorily. The remarkable checks that have been obtained comparing our regular method and the oxygen-acetate procedure will be noted from the table. The low form of crucible reduced the burning period nearly one half and allowed a temperature reduction in the muffle to 1500°F. We have found that a one-pound oxygen pressure gives the best results; however, it may be varied to suit the operator's convenience. Samples have been taken from the mill and results reported back to them in less than 45 minutes.

TABLE II  
COMPARATIVE DATA BETWEEN OXYGEN-ACETATE AND REGULAR METHOD

Sample	ASH		Calcium acetate solution N/4.2	Charge of flour	Oxygen pressure	Time of burning	Temperature
	5 hours regular	Oxygen-acetate					
	Per ct.	Per ct.	cc.	gm.	lb.	Min.	Deg. F.
A	0.423	0.423	2	3	1	15	1500
B	.386	.380	2	3	1	16	1500
C	.406	.400	2	3	1	15	1500
D	0.460	0.456	2	3	1	17	1500

### Summary and Conclusions

Experience with this method has proved it to be fast, accurate, and simple. Samples can easily be received and completed within 45 minutes. Porcelain crucibles of the low form and of 10 cc. capacity are satisfactory, while silica crucibles did not stand the test. A one-pound pressure on oxygen current is suggested. Oxygen costs us about a dollar a week, so the method is not a costly one. Length of time for delivery of oxygen into muffle depends upon number of samples, temperature, and oxygen pressure used. The ash resulting from the use of this method is of a light fluffy white character and takes up moisture very quickly, making fast and accurate balance work essential to success.

## COMPARISON OF THE OFFICIAL METHOD OF ASHING PLANT TISSUES AND PRODUCTS WITH THE HERTWIG AND BAILEY METHOD

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(Read at the Convention, June 11, 1926)

Ash determination by any method is tedious and probably productive of only relative results, but because of the large number of ash measurements that must frequently be made, a procedure which is accurate, and at the same time rapid, is one to be desired. The standard official method (1919) is accurate and dependable, but very slow, for it requires several ignitions of 6 or more hours each, in a muffle furnace at the proper temperature to bring the ash to constant weight. If necessary the soluble constituents should be leached out after the material has been charred. The Hertwig and Bailey method involves the use of a substance that will produce a porous coke when the ashing mixture is burned off before the crucibles are set into the furnace.

During an investigation on the Canada thistle at Iowa State College, it was necessary to determine the ash content. The method proposed by Hertwig and Bailey (1924), and tried out by eleven collaborators (1924) was found to be very satisfactory when used on the tissues of this plant. There was not enough material available to test out both methods upon it, so it was decided to try both on various plant tissues that are commonly ashed.

The materials used were sweet corn dried in the milk stage, apple wood, pea seeds, corn smut pores, and graham flour—substances high in sugars, cellulose, protein fat, and starch, respec-



tively. All these were finely ground before they were ashed by either method.

The procedure for the official and the Hertwig and Bailey methods is the same in most operations. In both, the samples were weighed out in covered crucibles, oven dried at  $105^{\circ}\text{C}.$  for 14 hours, and cooled in a desiccator for one hour before the first weighing was made, to obtain the oven-dry weight of the samples, which is the basis for calculation of ash percentages. The samples to be burned by the Hertwig and Bailey method were then treated in the way described in their original paper. When the alcohol and glycerol had been burned off, the crucibles for both methods were placed in the electric muffle furnace at the same time. The plug in the rear of the furnace was removed and the door left open as long as flames arose from the crucibles. The time of ignition was counted from the closing of the door after all flames had died down. Hertwig and Bailey found that two hours in the furnace was enough to bring the ash to constant weight when their mixture was used. This, therefore, was adopted as the time for each heating of the samples to be employed in the test of the new method. The time for the official method was taken as six hours in the same furnace beginning at the same time for equal numbers of test samples. The furnace at the Laboratory of Plant Physiology at Iowa State College, in which the work was begun, would hold only twelve Coors high form No. 0 porcelain crucibles without lids. The one in which the pea meal, spores, and flour were ashed would hold 20 Coors No. 1 crucibles without lids. In both furnaces there is left room for two rows of crucibles of the sizes available, between the last row and the door of the furnace.

The smaller furnace was kept at a dull red heat. In the first series of those run at the Laboratory of Plant Physiology at Colorado Agricultural College, a somewhat higher temperature,  $650^{\circ}\text{C}.$ , obtained. In Series II and III of the pea meal and the spores, a lower temperature,  $610^{\circ}\text{C}.$ , was found to be equally effective. The crucibles were cooled at least an hour, weighed with a cover, and ignition was repeated to constant weight.

No trouble was experienced in the complete combustion of the carbon in one heating with corn, wood, and smut spores. Pea meal required two heatings when the samples were large to bring them to constant weight, altho the two-gram samples in most cases were completely burned in one period in the furnace.

Experiments were conducted to determine the effect of the sizes of the sample on the number of burnings necessary to reach

constant weight. It was found that samples of more than two grams would not burn to a clear carbon-free ash in less than 18 hours with the official method, or in 6 hours with the Hertwig and Bailey method.

A comparison of the accuracy of the two methods is made in the tables which follow. The effects of the size of the sample and the temperature of ignition on the apparent ash content of the materials were investigated only in the work done at Colorado Agricultural College.

Considering first the ash of the sweet corn and the wood, which in reality constitute but one series, for they were run at the same temperature and ignited only once, it is seen that with corn the ash content does not appear to be higher by the Hertwig and Bailey method, but the estimation of the ash is more accurate because the average deviation is much smaller. The apparent percentage of the ash in most of the samples of wood as shown in Table II is higher in the Hertwig and Bailey method than in the official method.

TABLE I  
PERCENTAGE OF ASH IN SWEET CORN  
Average weight of sample, 3.6938 grams  
Temperature of ignition approximately 600° C.

Sample No.	Hertwig and Bailey method		Official method	
	Percentage of ash	Deviation from mean %	Percentage of ash	Deviation from mean %
I	2.86	0.06	2.83	0.14
II	2.86	.06	2.84	.13
III	2.91	.01	2.86	.11
IV	2.91	.01	2.84	.13
V	2.98	.06	3.08	.11
VI	2.97	.05	3.13	.16
VII	2.95	0.03	3.23	0.26
Mean percentage	2.92		2.97	
Mean deviation		±0.04		±0.15

Tables III and IV indicate the greater uniformity of the Hertwig and Bailey method when the conditions of the experiment vary, for in Series I and II of both tables, the samples were approximately the same size, and the temperature was changed. In Series II and III the temperature was held constant, and the size of the sample was varied. The difference between the percentages is so much greater than the average deviations that there is certainly some significance in the results. The apparent ash content by the official method varies exactly twice as much with the change of conditions as that of the Hertwig and Bailey method. Then, too, the size of the sample seems to have a greater influence upon the appar-

ent ash content in the official method than in the other one under investigation, altho the deviation from the mean with the official method is a little smaller.

TABLE II  
PERCENTAGE OF ASH IN APPLE WOOD TISSUE  
Average weight of sample, 1.1238 grams  
Temperature of ignition approximately 600°C.

Variety	Hertwig and Bailey method				Official method			
	Percentage of ash		Deviation		Percentage of ash		Deviation	
	Sample	Average %	from mean %		Sample	Average %	from mean %	
	I	II			I	II		
Ben Davis	2.56	2.59	2.575	0.015	2.46	2.66	2.56	0.10
Grimes	2.81	2.80	2.805	.005	2.69	2.74	2.715	.025
Jonathan	3.01	3.27	3.14	.13	2.93	3.01	2.97	.04
McIntosh	2.48	2.55	2.515	.035	2.44	2.50	2.47	.03
Malinda	2.22	2.36	2.29	.07	2.25	2.25	2.25	.00
Northwestern								
Greening	2.82	2.77	2.795	.025	2.85	2.78	2.815	.035
Oldenberg	3.48	3.46	3.47	.01	3.47	3.46	3.465	.005
Red Astrachan	3.36	3.40	3.38	.02	3.22	3.34	3.28	.06
Virginia	3.28	3.27	3.275	.005	2.94	2.99	2.965	.025
Wealthy	3.54	.....	.....	.....	3.34	3.26	3.30	.04
Winesap	3.06	2.80	2.93	.13	2.85	3.45	3.15	.30
Yellow								
Transparent	2.80	2.86	2.83	0.03	2.68	2.69	2.685	0.005
Mean deviation				±0.043				±0.055

TABLE III  
PERCENTAGE OF ASH IN PEA MEAL, 50-100 MESH

Sample No.	Hertwig and Bailey method		Official method	
	Percentage of ash	Deviation from mean %	Percentage of ash	Deviation from mean %
Series I, average sample 4.4506 grams Ignition temperature 650°C.				
I	3.16	0.00	3.11	0.01
II	3.16	.00	3.105	.005
III	3.16	.00	3.11	.01
IV	3.17	.01	3.095	.005
V	3.15	.02	3.10	.00
VI	3.16	0.00	3.10	0.00
Mean percentage	3.16		3.10	
Mean deviation		±0.005		±0.005
Series II, average sample 4.3508 grams Ignition temperature 610°C.				
I	3.17	0.02	3.14	0.01
II	3.19	.00	3.13	.00
III	3.20	.01	3.16	.03
IV	3.20	.01	3.13	.00
V	3.19	.00	3.12	.01
VI	3.19	0.00	3.12	0.01
Mean percentage	3.19		3.13	
Mean deviation		±0.0066		±0.01
Series III, average sample 1.3010 grams Ignition temperature 610°C.				
I	3.20	0.01	3.16	0.01
II	3.21	.02	3.19	.02
III	3.24	.05	3.19	.02
IV	3.23	.04	.....	.....
V	3.11	.08	3.13	.04
VI	3.15	0.04	3.17	0.00
Mean percentage	3.19		3.17	
Mean deviation		±0.04		±0.02



TABLE IV  
PERCENTAGE OF ASH IN CORN SMUT SPORES, 140 MESH

Sample No.	Hertwig and Bailey method		Official method	
	Percentage of ash	Deviation from mean %	Percentage of ash	Deviation from mean %
Series I, average sample 2.7294 grams Ignition temperature 650°C.				
I	5.13	0.08	4.82	0.01
II	5.14	.07	4.81	.02
III	5.26	.05	4.81	.02
IV	5.22	.01	4.79	.04
V	5.29	0.08	4.93	0.10
Mean percentage	5.21		4.83	
Mean deviation		±0.06		±0.04
Series II, average sample 2.3875 grams Ignition temperature 610°C.				
I	5.30	0.05	5.13	0.02
II	5.29	.06	5.16	.05
III	5.38	.03	5.06	.05
IV	5.38	.03	5.08	.03
V	5.38	0.03	5.12	0.01
Mean percentage	5.35		5.11	
Mean deviation		±0.04		±0.03
Series III, average sample 1.2553 grams Ignition temperature 610°C.				
I	5.31	0.02	5.06	0.01
II	5.24	.09	5.05	.00
III	5.34	.01	5.00	.05
IV	5.38	.05	5.03	.02
V	5.38	0.05	5.12	0.07
Mean percentage	5.33		5.05	
Mean deviation		±0.04		±0.03

The data in Table V show that with graham flour the Hertwig and Bailey method gives a very slightly higher ash content which, however, is not as great as any of the mean deviations and therefore renders this difference insignificant. They likewise indicate that these two means of obtaining the percentage of ash are about equally accurate for flour, so that the advantage rests with the method which involves the shorter time.

All the percentages in Tables III, IV, and V are based on the ash weight after the third ignition in each method. Thus each sample for the Hertwig and Bailey method was heated for a total of 6 hours, and each in the official method for 18 hours. It is quite obvious that not all the periods for ignition can be pressed into one day in any case. There remains to be solved, therefore, the problem of finding the shortest time for combustion that will insure constant weight without a repetition of the ignition and, for all but the most careful analyses, assure the investigator of acceptable results. The period of burning will probably be found to vary with the quantity and kind of material whatever the method employed.

TABLE V  
PERCENTAGE OF ASH IN GRAHAM FLOUR

Sample No.	Hertwig and Bailey method		Official method	
	Percentage of ash	Deviation from mean %	Percentage of ash	Deviation from mean %
Series I, average sample 4.5425 grams Ignition temperature 610° C.				
I	1.641	0.023	1.620	0.034
II	1.670	.006	1.655	.001
III	1.680	.016	1.631	.023
IV	1.655	.009	1.640	.014
V	1.649	.015	1.634	.020
VI	1.664	.000	1.642	.012
VII	1.655	.009	1.662	.008
VIII	1.680	.016	1.655	.001
IX	1.655	.009	1.659	.005
X	.....	....	1.682	.028
XI	1.676	.012	1.666	.012
XII	1.650	.014	1.679	.025
XIII	1.692	0.028	1.680	0.026
Mean percentage	1.664		1.654	
Mean deviation		±0.013		±0.016
Series II, average sample 1.8321 grams Ignition temperature 610° C.				
I	1.652	0.020	1.603	0.054
II	1.650	.022	1.641	.016
III	1.655	.017	1.675	.018
IV	1.686	.014	1.635	.022
V	1.650	.022	1.663	.006
VI	1.672	.000	1.656	.001
VII	1.685	.013	1.640	.017
VIII	1.741	.069	1.670	.013
IX	1.721	.049	1.698	.041
X	1.639	.033	1.619	.038
XI	1.677	.005	1.685	.018
XII	1.670	.002	1.658	.001
XIII	1.641	0.031	1.700	0.043
Mean percentage	1.672		1.657	
Mean deviation		±0.033		±0.022

### Conclusions

From the data at hand, it is clearly demonstrated that the difference in point of accuracy between the two methods is not great. It is also evident that with some kinds of plant products, or tissues, there is a higher apparent ash content by one method than by the other. This is true of substances which are rich in fat, such as corn smut spores. It is likewise suggested that the temperature of combustion may safely be higher with the process which involves the shorter ignition time. The saving of time alone, made possible by the Hertwig and Bailey method without any serious consequences in regard to accuracy and with the higher apparent ash content when constant weight is reached, makes this modification of the standard method worthy of careful consideration.

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## THE COMMERCIAL PROTEIN TEST ON WHEAT AND SOME OF ITS PROBLEMS<sup>1</sup>

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(Read at the Convention, June 8, 1926)

The application of the protein test to the buying and selling of wheat is a comparatively recent practice. There are many problems connected with this test which are not encountered in the research laboratory. The object of this paper is to discuss briefly the beginnings of the commercial protein test on wheat and consider some of the problems which have been encountered in Montana during the last year.

### History

#### Beginnings of the Commercial Protein Test

The protein test on wheat was first used by mills in December, 1900. Briggs (1926) of the Howard Wheat and Flour Testing Laboratory, which was established in 1886, has the following to say:

"It was in December, 1900, that I first made protein determinations, the test having been made previously in an experimental way on both flour and wheat and on dried gluten samples. To the best of my recollection, Seymour Carter, proprietor of the Gardner Mill at Hastings, Minn., was one of the earliest and most consistent users of this test. The reason why I recall this is that (probably in the summer of 1905) he said that as a result of using our protein tests with the great rust crop of 1904, he made more money from the mill that year than in several previous years. There were two or three other mills using the protein test at the same time."

From 1911 to 1914 there was an increased interest in the commercial protein test on wheat. It was during this time, according to Patterson (1926) and Durham (1926), that this test began replacing the old washed gluten test. Patterson describes this change as follows:

<sup>1</sup>Approved by the Director.



"In 1911-12 two or three mill chemists of the Southwest saw the absolute uncertainty of the inaccurate mechanical method of washing out gluten as a control production factor for the milling of uniform flour. In 1913 the wash gluten method in the Ismert-Hincke Flour Mills, of Kansas City, Kansas, was entirely eliminated, to be replaced by the Gunning method for the determination of nitrogen as a means of controlling the protein in the finished flour. In 1914 the American Association of Cereal Chemists passed a resolution that owing to the inaccurate mechanical method of washing gluten as a means of controlling the flour production, this method would be eliminated and the nitrogen determination substituted, using the factor 5.7 for converting nitrogen to protein. The premiums on wheat with a high protein content were not felt until about 1918 or 1919."

The adoption of the commercial test in Minneapolis since the World War is another outstanding event. Crosby (1926), of the Washburn Crosby Co., of Minneapolis, describes the manner in which this came about as follows:

"The mills here were running protein tests on wheat previous to the war, but preceding that time the wheat raised in this territory was much more of one type and consequently there was not the great range in milling qualities that exists at the present time. It is largely since the war that machinery in bakeries has changed materially, so that under their newer machinery a flour of higher protein is more desirable. For these two reasons—the change in the quality of the crops, and the demand by the bakers for high protein flours—protein has become one of the most important factors in the valuation of wheats. We made our first protein map of North Dakota in 1918. During the war there was no study of protein, as all wheat was allocated by the government. The value of the protein factor in wheat in the future may increase or decrease, depending upon not only the supply, but possible changes in the methods of handling flour in the bakeshops."

#### **Protein Tests by Grain Inspection Departments**

When protein content was accepted as one of the factors for determining the value of wheat, it naturally followed that the tests should be made by the same agencies that applied the federal grades on wheat. Accordingly the various grain inspection departments in the central and western states offered protein testing as a part of their regular services soon after 1920.

The first state grain inspection laboratory to offer the protein testing service was the Oregon Grain Inspection Department,

at Portland, early in 1921. Wright (1926) makes the following statement relative to the introduction of the protein test on the Pacific Coast:

"In reply to your letter of February 20 relative to the selling of wheat on a protein test on the Pacific Coast I wish to say that this department added a laboratory for protein tests early in 1921. Requests for this service were few until the last three years and each year has shown an increased demand for this service. No other grain inspection departments here on the coast offer the protein testing service, but the state of Washington is planning on installing a laboratory at Spokane and we are installing one in our inspection office at Astoria, Oregon."

The grain inspection laboratories offering the protein testing service in conjunction with the federal grades, at the present time, together with dates of installation, are as follows:

Oregon, at Portland .....	1921
Kansas, at Kansas City .....	1922
Kansas, at Hutchinson .....	1923
Kansas, at Wichita .....	1923
Montana, at Great Falls .....	1923
Nebraska, at Omaha .....	1924
Iowa, at Sioux City .....	1924
Minnesota, at Minneapolis .....	1925
Minnesota, at Duluth .....	1925
Wisconsin, at Superior .....	1925
Montana, at Bozeman .....	1925

### Problems in Commercial Protein Testing

The problems encountered by the chemist in commercial protein testing are quite different from those of the research chemist. Producers and dealers are unaccustomed to the protein test and there is occasionally scepticism in regard to all new tests. It is the chemist's job to obtain the confidence of his customers and to be able to explain any irregularities in tests which might occur. The problems discussed in this paper are (1) sampling, (2) moisture, (3) smut, (4) checking with other laboratories, and (5) interpretation of the protein test.

#### Sampling

Wheat is frequently sampled and tested for protein two or more times in as many markets. It is highly important that these tests agree within the allowable variation of two-tenths per cent.

In order to do this the sampling must be accurately done and every precaution taken to insure the proper cleaning and preparation of the test sample.

The question often arises as to whether it is possible for two laboratories to secure the same test of a car of wheat. In order to answer this question the Montana Grain Inspection Laboratory made a study of tests on duplicate samplings of 46 cars of wheat. The samples were taken with a grain probe from five places in the car as prescribed by the Office of Federal Grain Supervision. Care was exercised to take the duplicate samples in slightly different places from the original so as to detect any unevenness of loading of the grain. The tests were run in duplicate and the results computed on the basis of 13.5% moisture. The results of this study are shown in Table I.

The greatest range found in these 46 tests was 0.40%. Forty two of them showed 0.20% or less variation in the duplicate samples. This would indicate that in 91% of the cases two or more tests on a car of wheat might be expected to agree within the allowable variation of 0.20%.

A similar study was made on nine bins of wheat located on farms. Eight of these had tests agreeing within 0.16%. This would seem to indicate that proper sampling on the farm would **do** much toward securing uniform tests for producers. These data are given in Table II.

#### Relation of Moisture to Protein Content

Change of the moisture content of wheat is one of the most frequent causes of lack of uniformity of protein tests. The general practice in commercial protein testing is to disregard moisture content and report the tests without any moisture determinations. The chemists on the Pacific Coast and in other humid regions object to this because the grain coming from dry regions frequently arrives with 10% or less moisture and consequently has an abnormally high protein test.

It has been suggested by Cordu (1925) and others that this difficulty can be overcome by converting all protein tests to the uniform basis of 13.5% of moisture. This is objected to by producers and shippers in dry regions, because it will lower the protein test on their wheat. These people want the moisture basis placed at 10.5%.

It would seem that the fairer way would be to determine both the protein and moisture contents of the wheat as received and report both on the same certificate. This practice will doubtless



be objected to by some chemists because of the extra work involved, but it seems to deserve consideration.

#### Relation of Smut to Protein Content

The idea that smut in wheat causes an abnormally high protein test is very prevalent among farmers and dealers. However, tests made in the Montana Grain Inspection Laboratory do not bear out this belief.

Thirty-four samples of wheat, ranging in smut dockage from 1.4% to 6.0%, were tested for protein both before and after scouring. The data secured in these tests are given in Table III. All the samples of wheat in this study were treated in the same manner. They were run twice through an Emmerson dockage tester, after which 500-gram portions were run twice through a smut scourer. The greatest difference in protein content between the unscoured and scoured portions was 0.50%. Twenty-nine of the 34 smutty samples of wheat showed a difference of 0.20% or less in protein between the unscoured and scoured portions. There did not appear to be any consistent correlation between smut dockage and difference in protein content due to scouring. However, all the wheats studied which were classed as medium or light smut came within the limits of 0.20% protein as a difference between unscoured and scoured portions.<sup>2</sup>

The average protein content of the unscoured wheat was 12.28%, while that of the scoured was 12.17%, or a difference of 0.11% in favor of the former. It is worthy of note that 10 of the 34 tests on these smutty wheats showed no loss in protein when scoured free of smut. The change in protein content due to scouring ranged from a loss of 0.50% to a gain of 0.15%. This means that the scorings which were removed caused an average loss of 0.11% protein. Just what proportion of this was due to the smut removed in the scouring process is uncertain. In order to obtain some data on this point, 6 samples of wheat which were free from smut were scoured and tested in the same manner as those reported in Table III. The data for these smut-free wheats are given in Table IV. The greatest difference between the unscoured and scoured wheat was 0.15% as compared with 0.50%, which was the greatest difference found between the unscoured and scoured samples of smutty wheat. The average difference in protein be-

<sup>2</sup> In order to get some idea as to how much smut was actually present in wheat showing varying degrees of smut, pulverized smut balls were mixed with small lots of clean wheat in varying percentages of 0.5, 1, 2, and 3. The portion containing 0.5% classed as light smut, the one with 1% classed as medium smut, while the two with 2 and 3% respectively, both classed as heavy smut. The last group, that is, those classing as heavy smut, might in some instances cause a difference in protein greater than the allowable variation of 0.20%.

tween the unscoured and scoured portions of the smut-free wheat was 0.10% (which compared favorably with that of 0.11% for the smutty wheat). The average difference of 1.78% protein between the scouring dust and the unscoured wheat was the same as the 1.78% protein which was the average difference between the scouring dust and the unscoured wheat in the case of the smutty wheats.

A study of the amount of nitrogen present in pure smut balls was made as a means of explaining what might occur if a large amount of smut were included in a wheat sample for protein test. Eleven samples of wheat which contained appreciable amounts of unbroken smut balls were selected. The wheat and smut balls were both tested separately for nitrogen content and relative density. These data are given in Table V. Care was taken to have only the smut spores and the wheat bran which surrounded them enter into the analysis. Smut, both in the form of unbroken balls and pulverized, was dried at 135°C. in an air oven for 6 hours. A slight gain in nitrogen was found in both cases. This gain may be attributed to volatilization of the oils or to loss of water of combination. This indicates that the nitrogen in smut is present in a very stable form. The average nitrogen content of these pure smut balls in terms of protein was 18.00% while that of the wheat from which they were taken was 11.88%, a difference of 6.13%. The ratio of nitrogen in wheat to nitrogen in smut in these tests averaged 1:1.53, or in other words, nitrogen is one half more abundant in smut than it is in wheat. The relative density of smut balls and wheat was found by weighing an equal number of each. The average of the tests made showed wheat to be two and three-fourths times heavier than smut balls. Taking these two facts into consideration: namely, smut contains one-half more nitrogen than wheat, and wheat is two and three-fourths times heavier than smut, it will be seen that it is necessary to have a large amount of smut present to change the nitrogen reading materially.

This comparison of the loss in protein between smutty and non-smutty wheat when scoured seems to indicate that at least 0.10% or more of the difference might well be attributed to causes other than the presence of smut. The most logical explanation of this seems to be the high nitrogen content of the scouring dust from wheat when smut is not present. In other words, the smut in wheat, even tho it be high in nitrogen, does not ordinarily change the nitrogen reading of the wheat because of the relatively small amount present. A study has been started of the influence

on the protein test of washing smutty wheat in addition to scouring, but not enough progress has been made to warrant a statement.

#### **Checking With Other Laboratories on the Protein Test**

As previously mentioned, it is desirable that two or more protein tests on a car of wheat which are made in different markets agree closely. In order to bring this about the wheat must not have changed materially in moisture content or due allowance must be made for this factor, and it must be accurately sampled. If these conditions are met and it is granted that duplicate samplings of cars usually check as indicated in Table I, then the other variable is that of the analysis itself.

The importance of chemical laboratories checking closely is emphasized by Coleman, Fellows, and Dixon (1925). During the last year the Montana Grain Inspection Laboratory has maintained a check on control samples of wheat and flour with various laboratories. The results of these check tests for fifteen laboratories are given in Table VI. The range between the highest and lowest tests on wheat was 0.21%, while that on flour was 0.30%. The greatest deviation from the average was 0.10% for wheat and 0.18% for flour.

At the present time there is some criticism on the part of shippers in Montana that they do not receive the same tests on their wheat in different markets. This difference has been explained in certain cases by a change in moisture content. The details are not known in other cases. However, it seems that many of these discrepancies could not be attributed to errors in analysis.

#### **Interpretation of the Protein Test**

Bringing the protein test to the producers and dealers in such a way that they may understand what it means and apply it in their marketing operations is the problem of the cereal chemist. Grain traders have become accustomed to using the federal grades on wheat, but many of them are unaccustomed to applying the protein test and are sceptical of it. No doubt this condition will change materially during the next few years. It is believed that much can be done to popularize the protein test and help the trade to apply it more intelligently.

One of the outstanding criticisms at the present time is that there is too much variation in tests on the same wheat in different laboratories and in different markets. Experience has shown that a large part of this criticism is due to the fact that too much accuracy is expected of the protein test: When readings are reported



to the trade to two decimal places, as they are at present, too much emphasis is placed on small variations. This is a much closer reading than is given on any other test made on wheat with which the trade deals. In the testing of wheat for the application of the federal grades, readings are taken closely but applied on rather broad lines. Moisture is read to the nearest 0.2% but applied to 0.5%; test weight per bushel is read to the nearest 0.1 pound but applied only to the pound; dockage is read to the nearest 0.1% but applied to 1 per cent; and such factors as damaged kernels, foreign material, and mixed wheats are frequently determined to the nearest 0.1%, but applied to 1 per cent or more.

With these facts in mind would it not be well to place a little broader interpretation on the commercial protein test for the purpose of trading in wheat. Would not a reading to the nearest tenth or quarter per cent give as much information relative to the quality of a wheat as the present reading to two decimal places and at the same time be more easily understood by the average man who is trading in wheat.

The question naturally arises as to how "line samples" could be handled under an arrangement of this kind. Line samples, that is, samples of wheat which come in the borderline as to test weight per bushel or any other test, are always a rather difficult problem. However, it is fortunate that they do not occur frequently. When they do occur they are usually the basis of reinspection or federal appeal. Line samples in protein testing could well be handled in the same way.

From the standpoint of the protein base on which the differentials for fixing the price on wheat are computed, it seems that this system would also prove more workable than the present one. The price could be fixed much more readily on a protein reading which was already trimmed than on one which had to be adjusted to fit the occasion.

It will have to be granted that the protein test as a selling base for wheat is comparatively new. It will perhaps undergo many changes before it has the standing that the well known Babcock test on milk now has, but it seems desirable to do some constructive thinking as the various problems come up.

### Summary

This paper deals with the history of the commercial protein test on wheat and some of the problems which are encountered in applying it. The principal points are briefly summarized as follows:

1. The protein test on wheat was first used by mills in 1900. It was substituted for the old washed gluten test as early as 1911. Following the World War the protein test became generally adopted and soon was an important price-fixing element for hard wheat.
2. The Oregon Grain Inspection Department, in 1921, was the first to offer the protein testing service. Other inspection departments soon followed, and at present this service is rendered by eleven grain inspection departments.
3. Sampling is the first and most important step in commercial protein testing. Duplicate samplings of cars may be expected to check in 90% or more of the cases within the allowable variation of 0.20%.
4. Change in moisture content is one of the problems to be solved in the commercial protein test. It is recommended that the percentage of moisture of the sample tested be included as a part of the certificate.
5. The problem of smut in protein testing is not so important as it at first seems. The difference in protein between the unscoured and the scoured portions of several lots of smutty wheat was 0.11%. It is apparent that a large part of this difference can be attributed to causes other than smut.
6. Pure smut balls gave a reading of nitrogen equal to 18.00% protein on an average which was 1.53 times as great as the wheat from which they were separated.
7. Check tests among 15 laboratories on control samples of wheat and flour showed a range between the highest and lowest of 0.21% for the wheat and 0.30% for the flour. The greatest deviation from the average was 0.10% for the wheat and 0.18% for the flour.
8. A broader interpretation of the commercial protein test is recommended. It is believed that a reading to the nearest tenth or even quarter per cent will give as much information to the wheat buyer as the present reading to two decimal places.

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TABLE I  
PROTEIN TESTS ON DUPLICATE SAMPLINGS OF CARS OF WHEAT\*

Car No.	Protein %		Difference between the two tests
	First sample	Second sample	
12779	13.00	13.10	0.10
26000	15.05	15.08	0.03
507919	11.40	11.30	0.10
707027	11.85	11.90	0.05
502299	12.50	12.40	0.10
706694	12.90	12.65	0.25
709314	12.90	12.90	0.00
700175	12.95	13.00	0.05
709717	12.95	13.00	0.05
703136	15.10	14.95	0.15
710146	13.15	13.30	0.15
700739	13.95	14.05	0.10
700114	12.70	12.70	0.00
700913	15.40	15.45	0.05
707506	13.40	13.60	0.20
702636	13.80	13.80	0.00
507823	13.55	13.60	0.05
40045	13.85	13.85	0.00
710409	15.65	15.65	0.00
11059	13.90	14.00	0.10
10285	12.55	12.40	0.15
706421	13.65	13.35	0.30
24320	13.40	13.00	0.40
41766	11.15	11.05	0.10
703260	13.00	12.90	0.10
709314	12.75	12.80	0.05
713069	13.10	13.05	0.05
701548	11.70	11.60	0.10
706694	10.05	10.00	0.05
43993	15.10	15.00	0.10
708757	13.21	13.25	0.04
708514	10.45	10.49	0.04
705708 (brake)	12.81	12.89	0.08
705708 (non -brake)	14.68	14.32	0.36
28448	10.65	10.73	0.08
13926	14.76	14.64	0.12
13159	13.37	13.29	0.08
12232 (non-brake)	17.00	16.95	0.05
12232 (brake)	12.69	12.77	0.08
29740	13.49	13.41	0.08
25801	12.81	12.89	0.08
25720	13.57	13.61	0.04
705620	15.32	15.24	0.08
27139	12.49	12.57	0.08
503917	14.48	14.60	0.12
501333	14.04	14.00	0.04
Average	13.31	13.28	

Greatest range.....0.40%

Number of cars having difference of 0.20% or less.....42

\*These protein tests were all made in duplicate and computed on the basis of  
13.5% moisture.



TABLE II  
PROTEIN TESTS ON DUPLICATE SAMPLINGS OF BINS OF WHEAT ON FARMS\*

Bin No.	Protein %		Difference between two tests
	First sample	Second sample	
1	11.37	11.25	0.12
2	11.65	11.73	0.08
3	10.93	10.61	0.32
4	10.69	10.85	0.16
5	11.97	12.05	0.08
6	13.25	13.13	0.12
7	12.05	12.01	0.04
8	14.04	14.16	0.08
9	11.09	10.97	0.12
Average	11.89	11.86	0.12
Greatest range.....	0.32%		
Number of bins having difference of less than 0.20%.....	8		

\*Protein tests run as received.

TABLE III  
COMPARISON OF PROTEIN CONTENT OF SMUTTY WHEAT BEFORE AND AFTER SCOURING\*

Lab. No.	Description and degree of smut	Smut dockage %	Protein %			Differences	
			Unscoured wheat	Scoured wheat	Scouring dust	Unscoured wheat minus scoured wht.	Scouring dust minus unscoured wheat
7082	Heavy, balls	3.6	11.80	11.30	15.45	0.50	3.65
7567	Very heavy	2.0	12.55	12.10	13.90	0.45	1.35
7083	Heavy, balls	2.9	11.65	11.40	14.60	0.25	2.95
6925	Heavy, some balls	2.0	12.50	12.30	13.55	0.20	1.05
2238	Very heavy, balls	3.6	11.15	10.80	15.95	0.35	4.80
2243	Heavy, balls	1.6	12.90	12.60	13.15	0.30	0.25
5450	Heavy, balls	2.2	12.20	12.25	15.25	-0.05	3.05
7352	Heavy	2.8	15.05	15.10	14.40	-0.05	-0.65
6917	Heavy	2.5	10.90	10.80	14.10	0.10	3.20
7112	Heavy	2.5	10.70	10.65	14.10	0.05	3.40
7156	Heavy	2.0	12.40	12.40	13.80	0.00	1.45
6939	Heavy, balls	2.8	11.20	11.15	13.70	0.05	2.50
7177	Heavy	1.6	11.75	11.70	14.30	0.05	2.55
7134	Heavy	1.4	12.60	12.55	14.20	0.05	1.60
7130	Heavy	1.8	13.10	13.00	14.30	0.10	1.20
86	Heavy	3.0	13.70	13.70	15.45	0.00	1.75
183	Heavy	4.0	11.70	11.50	16.60	0.20	4.90
7261	Medium	1.6	12.55	12.45	13.60	0.10	1.05
7070	Medium	1.8	11.95	11.90	13.80	0.05	1.85
7106	Medium	2.3	10.90	10.80	13.40	0.10	2.50
102	Medium	2.0	10.40	10.30	13.45	0.10	3.05
103	Medium	1.5	12.40	12.40	13.30	0.00	0.90
1377	Medium	6.0	11.20	11.10	14.40	0.10	3.20
669	Medium	2.4	16.30	16.20	18.00	0.10	1.70
7383	Light	2.0	14.10	14.10	13.60	0.00	-0.50
6974	Light	1.7	13.50	13.40	12.70	0.10	-0.80
7314	Light	1.5	11.20	11.35	12.40	-0.15	1.20
7113	Light	1.4	12.45	12.25	13.55	0.20	1.10
6926	Light	1.8	11.45	11.45*	13.20	0.00	1.75
7155	Light	1.6	12.25	12.25	12.85	0.00	0.60
7291	Light	2.0	12.60	12.70	14.00	-0.10	1.40
7111	Light	1.5	9.35	9.30	11.90	0.05	2.55
7030	Light	1.5	12.20	11.90	13.60	0.30	1.40
7029	Light	1.8	14.85	14.65	13.55	0.20	-1.30
Average		2.2	12.28	12.17	14.06	0.11	1.78

\*These protein tests were all made in duplicate on the basis of 13.5% moisture.

The scouring dust was prepared for analysis by removing all foreign material such as chaff and sticks and pulverizing in a mortar. The material was then dried to a moisture-free basis.

TABLE IV  
COMPARISON OF PROTEIN CONTENT OF NON-SMUTTY WHEAT BEFORE AND AFTER SCOURING

Lab. No.	Loss in scouring %	Protein %			Differences	
		Unscoured wheat	Scoured wheat	Scouring dust	Unscoured wheat minus scoured wheat	Scouring dust minus unscoured wheat
104	1.3	15.35	15.45	16.70	0.10	1.35
7451	1.4	9.85	9.95	13.10	0.10	3.25
1422*	2.4	12.55	12.60	10.70	0.10	-1.85
105	1.1	9.85	9.90	13.60	0.05	3.75
7452	1.2	18.65	18.75	22.00	0.10	3.25
1417	1.5	12.20	12.35	13.10	0.15	0.90
Average	1.5	13.07	13.17	14.87	0.10	1.78

Greatest difference between unscoured and scoured wheat 0.15%.

\*No. 1422 was an immature sample of wheat that was frosted. The scouring dust had a lower percentage of protein by 1.85 than the unscoured wheat.

TABLE V  
COMPARISON OF NITROGEN IN WHEAT AND IN SMUT BALLS STATED IN TERMS OF PROTEIN

Lab. No.	Protein %		Ratio of nitrogen in wheat to nitrogen in smut	Ratio density of smut balls to wheat
	Wheat	Smut balls*		
2210	10.15	14.60	1:1.44	1:2.99
5450	12.20	18.20	1:1.49	1:2.70
6996	12.90	21.00	1:1.63	1:2.62
7146	11.75	15.10	1:1.28	1:3.04
6939	11.20	15.60	1:1.40	1:2.60
7177	11.75	18.80	1:1.60	1:2.68
7149	9.30	17.25	1:1.86	1:2.94
6999	13.40	21.50	1:1.61	1:2.71
7082	11.80	17.60	1:1.50	1:2.66
2238	11.15	17.45	1:1.62	.....
7352	15.05	21.00	1:1.39	1:2.56
Average	11.88	18.01	1:1.53	1:2.75

\*The smut balls were prepared for analysis by drying and then pulverizing in a mortar, after which the material was dried to a moisture-free basis.

TABLE VI  
PROTEIN TESTS BY VARIOUS LABORATORIES ON CONTROL SAMPLES OF WHEAT AND FLOUR PREPARED BY THE MONTANA GRAIN INSPECTION LABORATORY—1926

Lab. No.	Location	Protein %	
		Wheat	Flour
Montana Grain Inspection Laboratory, Bozeman		11.49	10.85
1	Great Falls, Mont.	11.46	10.72
2	Spokane, Wash.	11.45	.....
3	Seattle, Wash.	11.40	10.76
4	Portland, Ore.	11.47	10.73
5	Minneapolis, Minn.	11.55	10.90
6	Washington, D. C.	.....	10.94
7	Omaha, Neb.	11.36	10.65
8	Bozeman, Mont. (Chem. Dept.)	11.46	10.72
9	Minneapolis, Minn.	.....	10.95
10	Bozeman, Mont. (Station Chem.)	11.46	10.83
11	Portland, Ore.	11.45	10.70
12	Portland, Ore.	11.41	10.69
13	Portland, Ore.	11.43	10.68
14	Kansas City, Mo.	.....	10.72
Average		11.45	10.77

## VARYING CHARACTERISTICS OF THREE TYPES OF WHEAT GROWN UNDER THE INFLUENCE OF IDENTICAL ENVIRONMENT

By RALPH S. HERMAN

The Ismert-Hincke Milling Company, Kansas City, Mo.

(Received for publication, May, 1926)

This investigation was prompted by the erratic ash content evident on patent flours, as indicated in both experimental and commercial milling. During an investigation of certain milling and baking characteristics of wheats of varying origin and classification, of the 1925 crop, our attention was called to three particular samples of hard winter wheat which carried very interesting baking characteristics.

The three samples mentioned were obtained through the courtesy of Dr. S. C. Salmon, Professor of Agronomy, of the Kansas State Agricultural College, and represented true type samples of (a) Kharkof, (b) Blackhull, and (c) Kanred. These three samples were grown on the Kansas Agricultural Experiment Station experimental plots, in the same field, and under strictly comparable environment, particularly climatic conditions and soil. These samples, of course, are not to be considered as representative of either the crop or the type of wheat, being of primary interest because of their pronounced varying characteristics, even when grown under identical conditions.

The samples were very clean when received, and the berries plump and sound. The Kanred sample was of a dark vitreous character, while the Kharkof and Blackhull were slightly brighter in color. Weighed quantities of each variety were passed twice over an experimental milling separator and scourer. The Kharkof carried but 5 grams of screenings and 11 of chaff to 2000 grams of wheat; the Blackhull, 3 grams of screenings and 9 of chaff; while the Kanred had 14 grams of screenings and 13 of chaff to the same amount of wheat.

The samples were deliberately tempered alike, and altho all were calculated to the same roll wheat moisture, considerable actual variation in moisture was evident. Likewise the moisture content of the patent flour milled from the Kanred sample was very low, as was that of the clears from both the Kanred and the Blackhull.

The tempered samples of wheat were milled on the same date under strictly comparable conditions. An experimental reduction unit comprising two break rolls and two reduction rolls was em-



ployed for this purpose. Each sample was handled on the breaks six times, and the patent flour represents the troughs of the 11 XX cloth. The bran from the Kharkof and Kanred samples was broad and thin, while the Blackhull bran was broad and thick. The middlings in all three cases was large and sharp, with the Blackhull brightest in color.

TABLE I  
ANALYSIS OF CLEANED WHEAT

Variety	Kharkof	Blackhull	Kanred
Moisture, per cent	10.02	9.38	9.36
Ash, per cent	1.55	1.50	1.74
Ash calculated to 13.5% moisture	1.49	1.43	1.66
Protein (N x 5.7), per cent	13.89	15.89	17.57
Protein calculated to 13.5% moisture	13.38	15.25	16.77
Initial pH	6.56	6.51	6.61
Buffer pH	4.78	4.77	4.79
Viscosity without acid (A)	86	67	102
Viscosity with acid (B)	156	117	185
B - A	70	50	83
Increase over B with H <sub>2</sub> O <sub>2</sub>	120	59	130

Both the patent and the clear flours milled from the Blackhull sample were whiter and brighter than like grades from the other two wheats. This decided variation in color was also evident in the ground wheat meal used for the protein determinations.

TABLE II  
WEIGHT PER BUSHEL

Variety	Kharkof	Blackhull	Kanred
Before cleaning, lb.	61.5	62.5	60.0
After cleaning, lb.	63.0	64.0	62.5

TABLE III  
MILLING DATA

Variety	Kharkof	Blackhull	Kanred
Yield	4 bu. 48 lb.	4 bu. 46 lb.	4 bu. 44 lb.
Extract patent, %	55.7	55.2	55.4
Patent, %	82.1	80.4	80.5
Clear, %	13.5	14.7	14.8
Temper, hours	17.0	17.0	18.0
Roll wheat moisture, per cent	16.5	16.8	16.1

The analytical data covering the patent flours is particularly evident in variation, as indicated in Table IV, as regards the ash, protein, pH, and viscosity determinations. The very slight spread in per cent of extract patent (this is calculated by dividing the sum of the total products into the patent flour), and per cent of patent, is not sufficient to compensate for these fluctuations. It will be further noted from Table III that the milling yield is lower on Kanred, and this sample carries the highest ash content. The ex-

treme spread in pH, viscosity (Durham, 1925), and protein content is particularly interesting in connection with the characteristics evidenced in the various baking tests made on these samples, because of the unusually high protein content of the Blackhull and Kanred samples.

TABLE IV  
ANALYSIS OF UNBLEACHED PATENTS

Variety	Kharkof	Blackhull	Kanred
Moisture, per cent	12.90	12.18	11.64
Ash, per cent	0.39	0.37	0.40
Ash calculated to 13.5% moisture	0.39	0.37	0.39
Protein (N x 5.7), per cent	11.98	14.21	15.89
Protein calculated to 13.5% moisture	11.90	13.93	15.65
Initial pH	5.93	5.83	5.98
Buffer pH	4.12	4.00	4.00
Color dry*	BrLtCYVLtG	BrLtCW	BrLtCYLtG
Viscosity with acid (A)	332	386	529
Viscosity with acid +H <sub>2</sub> O <sub>2</sub> (B)	410	428	582
B-A	78	42	52
Per cent protein extraction	89.0	91.3	93.3

\*Key to grading: Br = bright, Lt = light, C = creamy, Y = yellow, G = gray, V = very, W = white.

The analytical data covering the clears was practically in line with the comparative relationship existing on the patents, as indicated in Table V.

TABLE V  
ANALYSIS OF UNBLEACHED CLEARS

Variety	Kharkof	Blackhull	Kanred
Moisture, per cent	11.70	10.86	10.38
Ash, per cent	0.49	0.44	0.49
Ash calculated to 13.5% moisture	0.48	0.43	0.47
Protein (N x 5.7), per cent	12.46	14.77	16.05
Protein calculated to 13.5% moisture	12.20	14.33	15.49
Initial pH	6.15	5.90	6.07
Buffer pH	3.99	3.96	3.90
Color dry*	DkYG	LtCYG	DkYG
Viscosity with acid (A)	310	424	455
Viscosity with acid + H <sub>2</sub> O <sub>2</sub> (B)	420	486	536
B-A	110	62	81

\*Key to grading: Dk = dark, Y = yellow, G = gray, C = creamy, Lt = light.

The baking tests extended over a period of two weeks. Each series with but one exception was baked in duplicate. The baking test employed in this series has been found to be very satisfactory and accurate in mill control work. It consists of certain modifications of the Werner (1925) method, particularly as relating to the method of handling the dough, and baking. The following formula was used: Flour 100 grams, sugar 2.5 grams, salt 1 gram, yeast 3 grams, and distilled water. The doughs were all mixed a definite

length of time by hand, with the temperature of the dough from mix, temperature during fermentation and proofing, and the proofing period held constant. The loaf volume was measured in an accurately calibrated seed displacement device.

With the exception of the series represented in Table VII, all bakings were made on the above outlined formula, with the fermentation period varied as indicated.

TABLE VI  
EXPERIMENTAL BAKING DATA ON 2:55 HOURS FERMENTATION, UNBLEACHED PATENTS

Variety	Kharkof	Blackhull	Kanred
Absorption, per cent	63.5	63	66
Fermentation period	2 hr. 55 min.	2 hr. 55 min.	2 hr. 55 min.
Proof, hr.	1	1	1
Crust color*	GlBrn	GlBrn	GlBrn
Crumb color	BrCY	BrLtCW	BrLtCY
Grain score and character	100 slsp	100 + slsp	101 el
Volume, cc.	450	445	500
Character of loaf	Well formed	Slight shell	Well formed

\*Key to grading: Br = bright, Lt = light, C = creamy, Y = yellow, sl = slight, sp = spherical, el = elongated, Brn = brown, Gl = golden.

The results of the first baking are given in Table VI and illustrated by Figure 1. In addition to the marked spread in loaf volume, the character of the grain varied. The Kanred grain was elongated and silky, while the Kharkof and Blackhull was more spherical in character. The crumb color was superior on Blackhull, but the loaf had a pronounced shell top.

TABLE VII  
EXPERIMENTAL BAKING DATA ON 2:55 HOURS FERMENTATION, UNBLEACHED PATENTS  
WITH 0.5 PER CENT ARKADY

Variety	Kharkof	Blackhull	Kanred
Absorption, per cent	66	65.5	69
Fermentation period	2 hr. 55 min.	2 hr. 55 min.	2 hr. 55 min.
Proof, hr.	1	1	1
Crust color*	DkGlBrn	GlBrn	DkGlBrn
Crumb color	BrCY	BrLtCW	BrLtCY
Grain score and character	100 + slsl	100 + slsp	101 el
Volume, cc.	475	450	515
Character of loaf	Well formed	Shell	Well formed

\*Key to grading: Br = bright, C = creamy, Y = yellow, Lt = light, Dk = dark, Gl = golden, Brn = brown, sl = slight, sp = spherical, el = elongated.

The three samples were next baked under the same method with the addition of 0.5 per cent of Arkady to the dough. This is represented in Table VII. The Blackhull loaf was not appreciably influenced. The relative spread, with the exception of the loaf volume, was the same as in Table VI. The Blackhull again produced a shell-top loaf.



The three samples were next baked in duplicate, using the same system as was used in the first baking, except that the fermentation period was increased to 4 hours and 30 minutes. As evidenced by Figures 2 and 3 and indicated in Table VIII, all three samples completely broke down. The character of the loaves both internally and externally was decidedly poor. The loaf volume showed an immense decrease, with Blackhull the greatest. The crumb color was superior on Kanred in this series.

TABLE VIII  
EXPERIMENTAL BAKING DATA ON 4:30 HOURS FERMENTATION, UNBLEACHED PATENTS

Variety	Kharkof	Blackhull	Kanred
Absorption, per cent	67.0	66.5	70.5
Fermentation period	4 hr. 30 min.	4 hr. 30 min.	4 hr. 30 min.
Proof, hr.	1	1	1
Crust color*	V pale	V pale	V pale
Crumb color	LtCYDu	LtCY	BrLtCY
Grain score and character	BD	BD	BD
Volume, cc.	335	305	335
Character of loaf	All three types of decided ragged formation, with pronounced shell tops.		

\*Key to grading: Lt = light, C = creamy, Y = yellow, Du = dull, Br = bright, V = very  
BD = broken down.

The fermentation period on the next series was reduced to 3 hours and 30 minutes, otherwise the method and formula were identical with the previous baking. As shown in Table IX and in Figures 4 and 5, Blackhull again had the smallest volume. The grain from Kanred was superior, being elongated in character, while the grain from Kharkof and Blackhull, particularly the latter, was decidedly spherical. The Kanred loaf was very bold, with good crust color, while the Blackhull loaf was pale and the Kharkof loaf was pale on the sides. The Blackhull loaf showed considerable breaking down of the grain structure.

TABLE IX  
EXPERIMENT BAKING DATA ON 3:30 HOURS FERMENTATION, UNBLEACHED PATENT

Variety	Kharkof	Blackhull	Kanred
Absorption, per cent	68	67.5	72
Fermentation period	3 hr. 30 min.	3 hr. 30 min.	3 hr. 30 min.
Proof, hr.	1	1	1
Crust color*	GlBrn	LtGlBrn	GlBrn
Crumb color	LtCY	LtCYVLTG	BrLtCY
Grain score and character	100 sp	100+ sp	101 el
Volume, cc.	445	395	490
Character of loaf	Well formed	Shell	Well formed

\*Key to grading: Gl = golden, Brn = brown, Lt = light, sp = spherical, el = elongated, V = very, C = creamy, Y = yellow, G = gray.

The series was next baked in duplicate with the fermentation period as the only variable from the previous series. This period was calculated from the pH of the flours, in order to have the

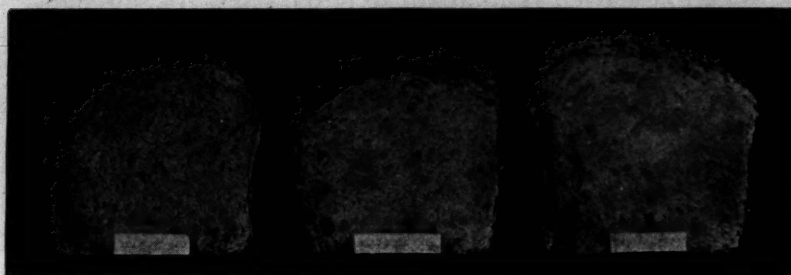


Fig. 1. Loaves from 2 hr. 55 min. Fermentation Period  
Left Kharkof; center, Blackhull; right, Kanred

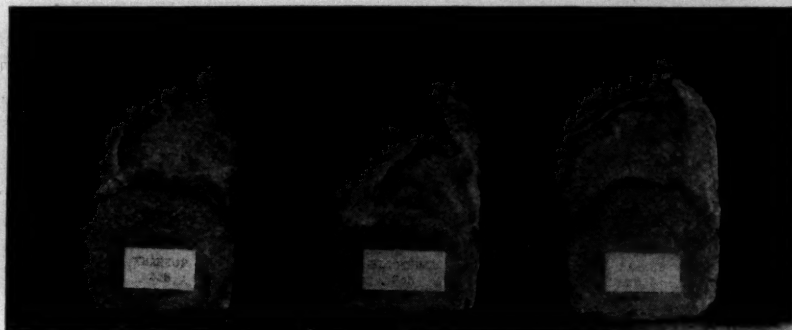


Fig. 2. Loaves from 4 hr. 30 min. Fermentation Period  
Left Kharkof; center, Blackhull; right, Kanred



Fig. 3. Loaves from 4 hr. 30 min. Fermentation Period  
Left Kharkof; center, Blackhull; right, Kanred

doughs go to the oven at approximately the same pH. As indicated in Table X, the fermentation on the Blackhull dough was held to 2 hours and 35 minutes; on the Kharkof, to 3 hours and 10 minutes; and on the Kanred, to 3 hours and 30 minutes. The loaf volume on this series was more nearly uniform, with the Kanred sample only slightly greater in volume than either the Blackhull or Kharkof. The three samples produced well-formed loaves, and the grain in all three was decidedly elongated, with Blackhull carrying slightly the tightest cell structure. The crust color was uniform, with Blackhull having the best crumb color, and Kanred slightly brighter than Kharkof. These loaves are illustrated in Figure 6.

TABLE X

BAKING TESTS OF UNBLEACHED PATENTS WITH BREAD BROUGHT TO A DEFINITE H-ION CONCENTRATION

Variety	Kharkof	Blackhull	Kanred
Absorption, per cent	67.5	66.5	71.0
Fermentation period	3 hr. 10 min.	2 hr. 35 min.	3 hr. 30 min.
Proof, hr.	1	1	1
Crust color*	GlBrn	GlBrn	GlBrn
Crumb color	LtCY	BrLtCW	BrLtCY
Grain score and character	100+ el	101 el	101 el
Volume, cc.	470	480	495
Character of loaf	All three types well formed.		
pH on bread 12 hr. old	4.90	4.89	4.97

\*Key to grading: Brn = brown, el = elongated, Gl = golden, Lt = light, C = creamy, Y = yellow, Br = bright, W = white.

### Summary

Results of experimental milling, and experimental baking tests are given as well as analytical data covering wheats, patent flour, and clear flour on three types of wheat grown under identical climatic and soil conditions.

The three types of wheat varied but slightly in milling qualities, while baking characteristics differed widely, and analytical variations were decidedly evident as regards ash and protein content, absorption, pH, and viscosity measurements.

The unusually high protein content of Kanred and Blackhull gave no indication of fermentation period, or possible margin of safety as relating to commercial usage of the flours.

The three wheats gave practically identical baking results, with the exception of crumb color and absorption, when handled on their individual approximate optimum fermentation period.





Fig. 4. Loaves from 3 hr. 30 min. Fermentation Period  
Left Kharkof; center, Blackhull; right, Kanred

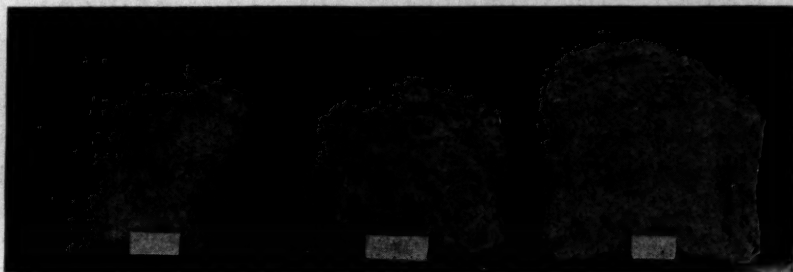


Fig. 5. Loaves from 3 hr. 30 min. Fermentation Period  
Left Kharkof; center, Blackhull; right, Kanred



Fig. 6. Loaves from Dough Calculated to a Definite pH  
Left Blackhull; center, Kharkof; right, Kanred

### Acknowledgments

Credit is given to the valuable assistance of William Meyer for the experimental milling and pH determinations, to Victor Hart for the baking determinations; to Max Markley for the moisture, ash, and protein determinations; and to R. K. Durham, of the Rodney Milling Co., for the viscosity measurements.

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## REPORT OF THE COMMITTEE ON STANDARDIZATION OF LABORATORY BAKING

By L. A. Fitz, Chairman

Your committee on Standardization of Experimental Baking Tests submits the following report:

Beginning with the tentative standard formula adopted at the last meeting, your chairman requested members of the committee to make baking tests in order to check up some changes that were made at the last meeting, giving special attention to the percentage of salt, as some members expressed to the committee the fear that the 1.54 per cent recommended would not be sufficient when distilled water was used. Of the nine members, two were not able to make baking tests. Two recommended an increase in amount of salt on account of flavor, two stated that 5 gm. of salt was satisfactory, and three did not report. Samples of flour were sent to eight members of the committee for baking test purposes. Three members reported in detail and one other sent bread to be scored. The results indicate a wide variation in dough time and proof time.

These results emphasized the necessity of reducing the variations due to the difference in technic of the operator. In order to study this problem, your committee arranged to meet at the laboratory of the Colorado Mill and Elevator Company on June 4 and 5 and make actual baking tests under conditions that were alike except for the personal equation. Six members of the committee reported and five made baking tests.

Altho all members were working under conditions more or less unfamiliar, and some of the members were decidedly out of practice, nevertheless the resulting bread showed more uniformity than the bread submitted by committee members at our last convention. There were variations in volume and texture due primarily to differences in working the dough and moulding the loaf.

As a result of this year's work your committee submits the following recommendations:

1. That we decide first just what an experimental baking test should show.
2. That a more accurate method of determining the total fermentation period be worked out. This should exclude mixing time and should include:
  - (a) Dough time, i. e., the time from placing dough in fermentation cabinet through first and second punches to
  - (b) Bench proof time, i. e., dough is replaced in cabinet for a short third rise.
  - (c) Pan proof time.(The dough time should be divided into 70 per cent for first rise and 30 per cent for second rise. Battery jars should be approximately 5 inches in diameter by 8 inches high.)
3. That a method of handling the dough be described in detail and subsequent arrangements be made to demonstrate and teach such method of dough handling.
4. That we recognize the fact that loaf moulding plays a very important part and that it is highly desirable that a suitable moulding machine be secured even if a special machine must be designed.
5. That the proper size and shape of baking pan for volume of dough used must be worked out. Your committee this year experimented with the style of pan commonly used by bakers for a 16-18 oz. loaf and the concensus of opinion is that this style of pan is too long, too wide, too shallow, and has too much flare to give best results. While this size and style of pan may be acceptable for a commercial bakery, it does not appear to meet the needs of a laboratory loaf prepared from a simple formula and hand moulded.



## **REPORT OF COMMITTEE ON METHODS OF ANALYSIS FOR AMERICAN ASSOCIATION OF CEREAL CHEMISTS**

Submitted by D. A. COLEMAN, Chairman

The Methods Committee appointed for the year 1925-26 consisted of C. B. Morison, R. B. Potts, A. R. Sasse, C. O. Swanson, G. A. Shuey, and D. A. Coleman.

Before proceeding with any investigations relative to methods of analysis, questionnaires were sent to the chairman of each of the various cereal chemists clubs asking for information relative to the difficulties each organization was having in making determinations for moisture, protein, and ash.

The substance of these questionnaires indicated that the organizations, as a whole, were satisfied with the methods of analysis now in use for making protein determinations.

Considerable difficulty, however, was still at hand concerning methods and technic for making ash determinations, particularly when the time element is considered.

A study of methods for making moisture determinations presented the usual difficulties. Recommendations were received for studying many methods with particular reference to the technic of the Brown-Duvel moisture tester and for the working out of a differential for the differences existing between the water-oven method of making moisture tests and the vacuum-oven test.

During the year the question was raised of reporting results of chemical tests on flour and feed on a definite moisture basis and efforts were made, especially by R. J. Clark, to make the various feed control officials see the wisdom of such a procedure.

Considering the many methods now in use for making the hydrogen-ion test, collaborative work was carried out with the point in mind of arriving at a simple procedure which would give concordant results in the hands of all.

The subject of flour sampling is attracting more attention every year. In conjunction with the officials of the American Association of Official Agricultural Chemists, a tentative method was worked over and is presented later in this report.

### **Collaborative Data on the Technic of Making Protein Determinations**

It appeared from the questionnaires that very little trouble was being had with the protein test proper, other than that of correct-

ly standardizing the receiving acids and titrating alkali, and the difficulty of obtaining a representative sample.

Dr. Swanson kindly carried out some very valuable and instructive tests planned to give information on the first point. He obtained samples of standard acid from over forty laboratories, and the normality of each sample submitted was checked by him as well as by R. K. Durham and A. A. Towner.

Many methods were used to standardize the acid tested by Dr. Swanson. Statements regarding the technic of standardization are given in the following paragraphs:

### 1. Barium Chloride Method for Sulphuric Acid

R. J. Clark, Goerz Flour Mills Company, Newton, Kan.

Draw off 25 cc.  $\text{H}_2\text{SO}_4$  solution, add 5 cc. of a solution made by putting  $2\frac{1}{2}$  cc. concentrated HCL in 57 cc.  $\text{H}_2\text{O}$  and then add 50 cc.  $\text{H}_2\text{O}$ . Heat to boiling and add 20 cc. boiling  $\text{BaCl}_2$  solution (1.62 grams  $\text{BaCl}_2$  in 90 cc.  $\text{H}_2\text{O}$ ) all at once with constant stirring for two or three minutes, then let stand. At the end of half an hour (after testing for complete precipitation) decant liquid through filter. Wash precipitate by decantation with hot water and subsequently upon the filter with hot water until filtrate is free of chlorine. Dry, ignite, and weigh. (Method is taken from George McPhail Smith's Quantitative Analysis. The author claims that there are unavoidable errors with the  $\text{BaSO}_4$  method but that using concentrations specified, the errors are kept to a minimum and tend to compensate.) Twenty-five cc. of exactly N/10  $\text{H}_2\text{SO}_4$  produces 0.29173 gm. of  $\text{BaSO}_4$ . After we standardize the sulphuric acid, holding ourselves to an error of one in the third decimal place in normality, we standardize our alkali by titration against the acid, using sodium alizarine-mono-sulphonate as an indicator.

### 2. Standardizing by Potassium Acid Phthalate

G. L. Alexander, Geo. P. Plant Milling Co., St. Louis, Mo.

The method of standardizing acid and alkali solutions is as follows: Dissolve 5 gm. of potassium acid phthalate in 50 cc. of recently boiled distilled water. Titrate with the alkaline solution, using as an indicator phenolphthalein which has been previously neutralized. If the solution is 0.1 normal, exactly 24.49 cc. of it will neutralize the 5 grams of potassium acid phthalate. The acid solution is standardized against the alkali, using methyl red as an indicator.

### 3. Standardizing by Oxalic Acid

A. R. Sasse, Southwestern Milling Co., Kansas City, Mo.

Weigh separately 6 portions (0.1579 gm. each) of recrystallized, uneffloresced oxalic acid into Erlenmeyer flasks and add 50 ml. of distilled water; 1 ml. of neutral 1% phenolphthalein solution; 19 ml. of the alkaline solution to be standardized, and boil for 2 minutes. Titrate further with the alkaline solution until a faint pink color is reached. The solution should be acid before boiling and if the 19 ml. makes the solution alkaline, a smaller quantity should be used. The average of the six titrations is accepted as the correct normality of the alkali.

The alkaline solution should be adjusted so that exactly 20 ml. will be required to neutralize the 0.1579 gm. of oxalic acid.

Sulphuric acid (0.1253 normal) is then prepared by titrating against the previously standardized alkali, using methyl red as the indicator. Methyl red is used in the standardization of the acid because it is the indicator used in the protein determination.

### 4. Constant Boiling Point HCl

M. J. Blish, Dept. of Agricultural Chemistry,  
University of Nebraska, Lincoln<sup>1</sup>

Make up HCl to a density of approximately 1.1, using a hydrometer. Distill off about three fourths of this from an ordinary distillation flask, and discard the distillate. Continue the distillation of the remaining one fourth, collecting this distillate in a separate container. This is the "constant boiling" acid, having a very definite composition which varies but slightly with variations in the atmospheric pressure at which the distillation is carried out. The desired amount of this acid is weighed out in an open dish on a sensitive balance. The open dish may be used, since the acid is already in equilibrium with the air.

The following table indicates the composition of constant boiling acid at various pressures, as well as the corresponding amounts necessary to give one gram-molecule of HCl. If this amount is diluted to 1 liter, one has an exactly normal solution of HCl. If diluted to 10 liters, one has exactly N/10 HCl.

For correcting weights to vacuum (brass weights) add 0.17 gm. for each mol. HCl.

<sup>1</sup> Jour. Am. Chem. Soc., Vol. 31, p. 390.



Pressure	% HCl	Gm. distillate for 1 mol. HCl
770	20.218	180.39
760	20.242	180.17
750	20.266	179.96
740	20.290	179.74
730	20.314	179.53
720	20.338	179.31

Only pure  $\text{CO}_2$ -free distilled water should be used for diluting the constant boiling acid to the desired strength. The water need not be boiled, but may be satisfactorily purified by aspirating it with air which first passes through soda-lime, until 1 drop of N/10 NaOH added to 200 cc. produces a distinct pink color in the presence of a few drops of phenolphthalein.

### 5. Standardizing by Potassium Bitartrate

O. W. Harper, Shellabarger Mills, Salina, Kan.

Primary standard potassium bitartrate C. P. molecular weight 188.16. Theoretically, if it were possible to dissolve 188.16 gm. of  $\text{KHC}_4\text{H}_4\text{O}_6$  in 1000 cc. of distilled, boiled water, we would have a primary normal standard, of which 100 cc. would contain 18.816 gm. of  $\text{KHC}_4\text{H}_4\text{O}_6$ . Fifty cc. would contain 9.408 gm. of  $\text{KHC}_4\text{H}_4\text{O}_6$  but it is impossible to get this to stay in solution when cold so one can weigh out a definite known quantity of this primary standard in an excess of water and proceed. For a tenth-normal solution, weigh out 0.9408 gm. in an excess of water and dissolve by heating. This solution is equivalent to 50 cc. of tenth-normal sodium hydroxide. It is more convenient to use the equivalent of 25 cc. of tenth-normal sodium hydroxide, which is 0.4704 gm. of  $\text{KHC}_4\text{H}_4\text{O}_6$ . This is then weighed and emptied into a 250-cc. Erlenmeyer flask, about 50 cc. of distilled water added, and brought to a boil. Then with a No. 18 wire on the tip of a lead pencil add the amount of dry phenolphthalein indicator powder which will just stay on the tip of wire and bring to a boil and titrate while still hot. The unknown alkali is run in from the burette, and as soon as a pink color appears the reaction or neutralization is assumed to be complete, i. e., 0.4704 gm. of potassium bitartrate is equivalent to 25 cc. of tenth-normal sodium hydroxide.

25 cc. = amount that should be needed to neutralize

24.9 cc. = amount that was needed to neutralize

$24.9 : 25 :: 0.100 : x$

$x - 0.100401$  = normality of present alkali

then acid against present alkali

20 cc. = amount that should be needed

20.1 cc. = amount needed

$20.1 : 20.0 :: 0.1004 : x$

$x = 0.09990$  = normality of the acid.

#### 6. Weighing Ammonium Sulphate

Thos. W. Sanford, Eagle Roller Mill Co., New Ulm, Minn.

Distill over ammonia into a receiving flask containing 25 cc. acid. When neutralized, transfer to a weighed evaporating dish and place in a drying oven over night. Then calculate to sulphuric acid from the weighed ammonium sulphate.

#### 7. Weighing Standard $H_2SO_4$

C. K. Kress, Sperry Flour Co., Vallejo, Calif.

We make approximately a 52% sulphuric acid solution which is nearly at equilibrium with the usual laboratory humidity. This is standardized very carefully with sodium carbonate and by determining as barium sulfate. After determining the exact strength of this concentrated solution it is simply a matter of weighing on a balance the amount required to make any quantity and normality desired. A large enough quantity of the concentrated solution is made at one time to last for several years.

This method is fully described in "Methods of Analysis," by Scott, pages 502 and 503.

We also check each lot of standard acid as made up for protein use by determining its voltage. We use N/8 acid and its voltage is 0.3135. An error in the strength of this acid sufficient to cause an error of 0.1% in a protein determination will change the voltage 0.0020, which is a marked difference and easy to read at that acidity.

#### 8. Standardizing Against Benzoic Acid

H. L. Lentz, Robinson Milling Co., Salina, Kan.

In standardizing N/10 NaOH, use a Bureau of Standards 50-cc. burette and a sample of 100% pure benzoic acid obtained from Bureau of Standards. Weight out 0.4883 gm. benzoic acid, dissolve

in 10 cc. alcohol, add 10 cc. distilled  $H_2O$ , and titrate cold against  $N/10$  NaOH. When exactly  $N/10$ , 40 cc. should be required. Then run a blank with 10 cc. alcohol and 10 cc.  $H_2O$ . Use phenolphthalein as indicator. If unable to obtain ethyl alcohol, use C. P. methyl alcohol.

A summary of the results of the comparative tests obtained by Dr. Swanson is given in Table I.

Summarizing his work Dr. Swanson states:

"It appears from the data we obtained that there is no great difference in the accuracy with which the various acids can be standardized by the use of any specific method. It seems that the method makes less difference than the individual skill of the chemist."

In standardizing reagents, volumetrically short cuts, of course, are accomplished, but even so it is well to keep in mind the following information submitted by the U. S. Bureau of Standards.

"The limit of accuracy of volumetric analysis is about one part in 500 unless special precautions are taken. Uncalibrated apparatus has been found to give errors very much in excess of this ratio."

"A solution standardized at  $20^\circ C$ . and used in a correctly calibrated burette will be in error one part in 1000 if used at  $25^\circ C$ . and no account taken of the expansion of the solution due to rise in temperature."

"The accuracy in reading the burette exerts another limiting effect upon the accuracy of the result as well as the ability of the analyst to bring the solutions titrated to the same degree of neutrality. When all of these conditions are considered, accuracies of one part in 500 are considered satisfactory and the expression of results to a greater degree of accuracy has no significance."

### Sampling Studies

Altho it may perhaps be a little beyond the province of the committee on methods of analysis to discuss car sampling, it should be pointed out that the obtaining of a representative sample is absolutely essential, as no amount of care in making subsequent determinations will establish the protein content if a representative sample has not been taken. Correct car sampling seems to offer considerable difficulty, especially when the samples contain an excess amount of dockage. Large differences in the protein content of such cars have been reported from time to time.



TABLE I  
NORMALITY OF ACIDS USED IN PROTEIN DETERMINATIONS AS REPORTED AND FOUND

Serial No.	Name of mill	Chemist	Method of standardizing	Normality as given	Normality as found	Factor
36	G. P. Plant Mfg. Co.	Alexander, G. S.	Potassium acid phthalate	0.0996	0.0877	0.881
14	Nebr. Expt. Sta.	Blish, M. J.	Const. boiling point HCl	.1000	.1005	1.005
24	Ogden, Utah	Buford, G. H.	Benzoic acid, stated on bottle	.1000	.0990	.990
35	Globe Gr. Mfg. Co.	Bulena, H. G.	BaSO <sub>4</sub>	.2000	.1982	.991
23	Blair Mfg. Co.	Clark, H. W.	BaSO <sub>4</sub>	.1000	.0987	.987
22	Goerz Milling Co.	Clark, R. J.	BaSO <sub>4</sub>	.1000	.1002	1.002
11	Midland Mfg. Co.	Curtiss, A. E.	No method given	.1270	.1287	1.013
38	Fort Worth Labs.	Dunning, G. R.	BaSO <sub>4</sub> , Ag Cl, Calcite	.5000	.5002	1.000
18	Fort Worth Labs.	Dunning, G. R.	BaSO <sub>4</sub> , Ag Cl, Calcite	.2000	.2007	1.004
3	St. Joseph Testing Lab.	E. C. E.	Standard method	.10	.1004	1.004
17	J. C. Lysle Milling Co.	Earlenbaugh, L. E.	BaSO <sub>4</sub>	.1340	.1368	1.021
5	Standard Tilton Mill	Fisher, V. E.	BaSO <sub>4</sub> , stated on bottle	.10	.1249	1.249
15	Sherman Gr. and Cotton Exchange	Frank, W. L.	BaSO <sub>4</sub> , Ag Cl, NaHCO <sub>3</sub>	.1019	.1002	.984
1	Kansas Flour Mill	Frye, R. L.	Const. boiling pt. HCl	.1253	.1243	.992
30	Clay Center Test. Lab.	Hall, Walter	Benzoic acid	.0998	.0985	.987
19	Shellabarger Mill Co.	Harper, O. W.	Potassium, bitartrate	.0999	.1002	1.003
16	Ismert-Hincke Mfg. Co.	Herman, R. S.	No method given	.1000	.1010	1.010
33	J. F. Imbs-Mfg. Co.	Imbs, J. J.	NaH CO <sub>3</sub> or Na <sub>2</sub> CO <sub>3</sub>	.1000	.0987	.987
12	Gooch Milling Co.	Johnson, H. H.	Oxalic ac. & K ac. phthalate	.1010	.1027	1.010
37	Sperry Flour Company	Kress, C. B.	BaSO <sub>4</sub> Na HCO <sub>3</sub> , conductivity	.1250	.1248	.998
34	Robinson Mfg. Co.	Lentz, H. L.	Benzoic acid	.100250	.1012	1.010
29	N. D. Exp. Sta.	Mangels, C. E.	BaSO <sub>4</sub>	.0714	.0712	.998
8	Arnold Madus Mfg. Co.	McVey, R. V.	BaSO <sub>4</sub>	.1009	.1007	.998
9	Omaha Gr. Exch. Lab.	Mize, M. D.	BaSO <sub>4</sub> , Potassium ac. phthalate	.1254	.1258	1.003
25	Burrus Mill Co.	Newell, C. T.	BaSO <sub>4</sub>	.10041	.1002	.998
28	Int. Mfg. Co.	Olsen, Leslie	BaSO <sub>4</sub>	.097	.0974	1.004
27	Lawrenceburg Roller Mills Company	Oppen, C. O.	No method	.2000	.1997	.999
39	Maney Mfg. Co.	Rosse, E. J.	BaSO <sub>4</sub> , stated on bottle	1.012	1.002	.991
4	New Ulm, Minn.	Sanford, T. W.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> , K acid phthalate	.1245	.1248	1.002
2	S. W. Mfg. Co.	Sasse, A. R.	Oxalic acid	.1253	.1253	1.000
7	Minn. State Mill	Sherwood, R. C.	Ag Cl	.07126	.0707	.992
10	Washburn Crosby (K. C.)	Tibbling, E. F.	BaSO <sub>4</sub> , Succinic acid	.1250	.1257	1.006
20	Red Star Mill Co.	Towner, A. A.	BaSO <sub>4</sub> , Benzoic acid	.1004	.1010	1.006
31	El Reno Mill Co.	Vaupel, H. F.	BaSO <sub>4</sub>	.1000	.1012	1.012
32	Hunter Mill Co.	Ward, C. E.	BaSO <sub>4</sub>	.1001	.1007	1.006
21	Quaker Oats Co.	Warren, M. R.	BaSO <sub>4</sub>	.1000	.1007	1.007
13	A. D. Wilhoit Lab.	Wilhoit, A. D.	NaHCO <sub>3</sub> , FeSO <sub>4</sub> (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> 6H <sub>2</sub> O	.2506	.2501	.998
6	Scott Co. Mfg. Co.	Wood, J. C.	BaSO <sub>4</sub> , Benzoic acid	.199	.2006	1.008
26	Pillabury Flour Mills Co. (Minn.)		BaSO <sub>4</sub> , stated on bottle	0.0953	0.0962	1.010

To H. C. Fellows and H. B. Dixon, of the Research Laboratory of the Grain Division of the Bureau of Agricultural Economics, we are indebted for the following data relative to the protein content of the duplicate car samplings of about 250 cars of wheat as they arrived at the Minneapolis market. Some of these cars contained as high as 15 per cent of dockage and represent receipts which were loaded in an even and uneven manner.

Each car was sampled twice by means of the usual grain probe in five different areas in the manner illustrated in Figure 1. The contents of probes 1 to 5 and 6 to 10, inclusive, were composited separately, thoroly cleaned, mixed, and reduced to 75 gm. in size to be ground for making protein tests. The results are given in Table II. Moisture determinations were made when the protein tests were made so that the results reported are on a uniform moisture basis.

TABLE II  
VARIATION IN PROTEIN RESULTS OBTAINED FROM THE ANALYSIS OF DUPLICATE  
SAMPLINGS OF 241 CARLOTS OF SPRING WHEAT

Number of samplings	85	56	53	27
Per cent of variation in duplicate tests	0—.04	.05—.09	.10—.14	.15—.19
Per cent of total samplings	35.2	23.2	22.0	11.2

Number of samplings	10	2	4	8	2
Per cent of variation in duplicate tests	.20—.24	.25—.29	.30—.34	.35—.39	.40
Per cent of total samplings	4.2	.8	1.7	.8	.8

The results of these tests show that over 96 per cent of the tests varied by less than 0.25 per cent, a value which, it will be remembered, this organization approved last year as being permissible.

It is evident, therefore, that car lots of wheat can be sampled several times with a reasonable degree of accuracy, in order to arrive at a correct analysis of their protein content.

#### Recommendations of the Committee Regarding Protein Determinations

As a result of the collaborative work carried out by previous committees, as well as from a study of the data accumulated by the committee this year, the following method is recommended for adoption by the association for making protein tests on wheat, flour, and mill feeds.

### Method Recommended for Making Protein Tests

#### Obtaining the Wheat Sample

A representative sample is essential to the determination of the true grade of a given lot of grain. If the sample obtained is not representative, no amount of care in making determinations will establish the protein content of the grain. Consequently, great care should be taken in order that the sample on which the protein of the grain is to be based shall truly represent the grain sampled.

In order to obtain a representative sample, the following instructions should be followed.

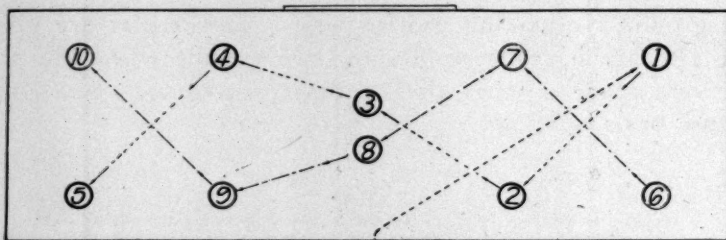


Fig. 1. Showing Method Used in Sampling Wheat for the Duplicate Sampling Test Described in the Text. Arrows show the sequence.

#### Cleaning Sample

Wheat samples should not be analyzed for protein content until dockage has been removed. Dockage includes sand, dirt, weed seeds, weed stems, chaff, straw, grain other than wheat, and any other foreign material which can be removed readily from the wheat by the use of appropriate sieves, cleaning devices, or other practical means suited to separate the foreign material present; also undeveloped, shriveled, and small pieces of wheat kernels removed in properly separating the foreign material, and which can not be recovered by properly rescreening or recleaning.

#### Removing Dockage

Such sieve or sieves should be used as will remove the foreign material with the least possible loss of wheat, including small, plump, or badly shriveled kernels, or large pieces of broken kernels.

The details for the method for removing dockage are given in U. S. Grain Standards Act, Handbook of Official Grain Standards Form 90.



### Dividing Sample for Test

After a representative sample of the lot of grain is obtained, it is usually necessary to reduce its size considerably. To reduce the size of a sample of grain containing foreign substances of different specific gravity or size than of the grain with which they are mixed and at the same time obtain a sample as representative as the original, is hardly possible except by mechanical means.

A device, generally referred to as the "Boerner sampler," which will divide a sample into small portions and still maintain the proper proportions for the various factors of the original sample, is ideal for this purpose.

The device and a simplified form of it are fully described in the United States Department of Agriculture Bulletins 287 and 857.

### Grinding Sample Preparatory to Chemical Analysis

Grind 30-40 gm. of wheat on a burr mill to such a degree of fineness that it will all pass through a 36 grits gauze sieve. The burr mill should always be kept in a cool condition. The ground material should be immediately placed in a suitable air-tight container of such size as to allow intimate mixing of the sample.

The grinding apparatus should be thoroly cleaned before each new sample of wheat is ground. This may be accomplished by dissembling the mill or by passing a sufficient quantity of new sample through the burrs that all traces of previous sample will be entirely removed.

### Chemical Reagents Necessary for Making Protein Test Receiving Acid

For ordinary work N/8 or less acid is recommended. For standardizing hydrochloric and sulfuric acid the following methods are suggested.

#### Standard Hydrochloric Acid

(a) Determine the absolute strength as follows: Preliminary test: Place a measured portion of the acid to be standardized in an Erlenmeyer flask with excess of calcium carbonate to neutralize free acid and a few drops of potassium chromate as indicator. By titration with silver nitrate solution determine exactly the quantity required to precipitate the chlorides. Final determination: To a measured portion of the acid to be standardized add from the burette one drop in excess of the required quantity of silver nitrate solution as determined by the preceding test. Heat to boiling.

protect from light, and allow to stand until the precipitate is granular. Filter on a tared Gooch crucible, previously heated to 140°-150°C., wash with hot water, testing the filtrate to prove excess of silver nitrate. Dry the silver chlorid at 140°-150°C., cool, and weigh.

**Standard Hydrochloric Acid (Constant Boiling Acid)**

(*Jour. Am. Chem. Soc.*, Vol. 31, p. 390.)

(b) Make up HCl to a density of approximately 1.1, using a hydrometer. Distill off about three fourths of this from an ordinary distillation flask, and discard the distillate. Continue the distillation of the remaining fourth, collecting this distillate in a separate container. This is the "constant boiling" acid, having a very definite composition which varies but slightly with variations in the atmospheric pressure at which the distillation is carried out. The desired amount of this acid is weighed out in an open dish on a sensitive balance. The open dish may be used, as the acid is already in equilibrium with the air.

The following table indicates the composition of constant boiling acid at various pressures, as well as the corresponding amounts necessary to give one gram-molecule of HCl. If this amount is diluted to 1 liter, one has an exactly normal solution of HCl. If diluted to 10 liters one has exactly N/10 HCl.

Pressure	% HCl	Gm. distilled for 1 mol. HCl
770	20.218	180.39
760	20.242	180.17
750	20.266	179.96
740	20.290	179.74
730	20.314	179.53
720	20.338	179.31

For correcting weights to vacuum (brass weights), add 0.17 gm. for each mol. HCl.

If no barometer is available, the barometric pressure may be obtained by calling up the local weather office. It is to be noted, however, that an error of several millimeters would effect no very appreciable error in the final solution.

Only pure CO<sub>2</sub>-free distilled water should be used for diluting the constant boiling acid to the desired strength. The water need not be boiled, but may be satisfactorily purified by aspirating it with air which first passes through soda-lime, until 1 drop of N/10 NaOH added to 200 cc. produces a distinct pink color in the presence of a few drops of phenolphthalein.

If these directions are all carefully followed one cannot fail to obtain exact solutions if the weights and measuring apparatus are accurate. The method is not only extremely accurate, but it requires relatively little time and attention. It is practically fool-proof, and does away with the necessity of relying upon purity of reagents.

#### Standard Sulphuric Acid

(c) Determine the absolute strength of the acid by precipitation with barium chloride solution as follows: Dilute a measured quantity of the acid to be standardized to approximately 100 cc., heat to boiling, and add drop by drop a 10 per cent solution of barium chlorid until no further precipitation occurs. Continue the boiling for about five minutes, allow to stand for five hours or longer in a warm place, pour the supernatant liquid on a tared Gooch crucible or an ashless filter, treat the precipitate with 25-30 cc. of boiling water, transfer to the filter, and wash with boiling water until the filtrate is free from chlorides. Dry, ignite over a Bunsen burner, and weigh as barium sulfate.

For those who interpret their results in terms of the standard alkali, the use of potassium acid phthalate, benzoic acid, or oxalic acid as standard reagents is permissible.

Promiscuous cross-titrations should be discouraged. As has been pointed out earlier, the limit of accuracy of volumetric analysis is about one part in 500 unless very special precautions are taken.

**Standard alkali solution.**—Accurately determine the strength of this solution by titration against standard acid. Not greater than N/8 alkali is recommended.

**Sulfuric acid.**—Should contain 93-96 per cent of  $\text{H}_2\text{SO}_4$ , have a specific gravity of 1.84, and be free from nitrates and ammonium sulfate.

**Mercuric oxid** (red, free from nitrates), granulated zinc or pumice stone.

**Powdered anhydrous sodium or potassium sulfate** free from nitrogen.

**Sodium sulfide or sodium thiosulfate.**—Use 40 grams of sodium sulfide or 80 grams of sodium thiosulfate per liter.

**Sodium hydroxide solution.**—A saturated solution sp. gr. 1.43-1.48 in which is dissolved the mercury precipitant.

**Methyl red indicator.**—Dissolve one gm. of methyl red in 100 cc. of 95 per cent alcohol.



### Apparatus

**Distillation flasks.** For distillation, any suitable flask of about 550 or 800 cc. capacity may be used. It is fitted with a rubber stopper through which passes the lower end of a Kjeldahl connection bulb to prevent sodium hydroxid being carried over mechanically during the distillation. The bulb should be about 5 cm. in diameter and the outlet tube should be of the same diameter as the condenser tube with which the upper end of the bulb is connected. A double lipped connecting bulb is preferable.

### Digestion and Distillation Apparatus

The most essential feature of the digestion and distillation apparatus is the heating units, as heat is the most outstanding factor in the matter of securing rapid protein tests.

If the digestion apparatus is electrically heated, at least one hour digestion is needed for burners wired to deliver 440 volts, at least 45-50 minutes for burners wired to deliver 550 volts, and at least 40-45 minutes for burners carrying 600 volts or more.

The heaters on the distillation apparatus should be adjusted to develop heat enough to distill over 150 cc. of water in 25-30 minutes.

### Determination

Place 1 gm. of the sample in a digestion flask together with approximately 10 gm. of a mixture containing by weight 6 gm. of potassium sulfate, 4 gm. of sodium sulfate, and half a gm. of red mercuric oxid. Add 20 cc. of sulphuric acid; thoroly mix the acid, salts, and sample together and digest completely. Cool, dilute with 200 cc. of distilled water, add a few pieces of granulated zinc or pumice stone. Next add sufficient sodium hydroxide and thio-sulfate solution or sodium sulfide to make the solution strongly alkaline and to precipitate the mercury, pouring the alkali down the side of the flask so that it does not immediately mix with the acid solution, 50 cc. being usually enough.

Connect the flask with the condenser, mix the contents by shaking, and distill until all the ammonia has passed over into a measured quantity of standard acid. The first 150 cc. of the distillate will generally contain all the ammonia. Titrate with standard alkali. Calculate first into terms of nitrogen, later into protein by multiplying the percentage of nitrogen found by 5.7. For mill feeds the factor 6.25 should be used.

Reagents should be tested for absence of nitrogen by making a blank with sugar. The sugar partially reduces any nitrates present that otherwise might escape notice. Deduct any nitrogen found in the reagents from that found under the conditions of the test.

### Collaborative Work on Ash

The ash studies carried out by the association this year were planned with the idea of comparing the efficiency of several rapid methods with the standard method of the Association of Official Agricultural Chemists.

To accomplish this work, laboratories were chosen which were equipped with and without temperature control on their ashing ovens.

Short patent, standard patent, and first-clear flours milled from Montana wheat were used for study. This selection of material was made (1) because of the known difficulty in ashing flours milled from Montana wheat, and (2) because of the desire to know whether, by methods proposed, flours of high and low ash content could be efficiently handled.

The methods selected follow:

Method 1.—The method usually employed in the collaborators' laboratory.

Method 2.—The method of the Association of Official Agricultural Chemists, which is as follows:

Weigh 3-5 grams of the well-mixed sample into a shallow relatively broad ashing dish which has been ignited, cooled in a desiccator, and weighed soon after attaining room temperature. Incinerate in a furnace at approximately 550°C. (dull red) until a light gray ash results, or until no further loss in weight occurs. Cool in the desiccator and weigh soon after room temperature is attained.

Re-ignited quick lime or calcium carbide is a satisfactory drying agent for the desiccators.

Method 3.—The Bailey-Hertwig Method.

Mix 3-5 gm. of flour in the ashing dish with glycerol-alcohol solution (made from equal volumes of each). Use 1.5 cc. of the glycerol-alcohol solution for each gram of flour used. Clean the mixing rod with a small piece of ashless filter paper. Ignite the paper and alcohol. After the alcohol has been burned off, place in an electric muffle held at 575°C.

and burn to a white ash. Place in an efficient desiccator, weigh when cool. Note the time for complete ashing. If technical glycerol is used, run a blank determination.

Method 4.—The Glacial Acetic Acid Method.

Reagents—

Acetate solution—Prepare a solution of calcium acetate by dissolving 1 gm. C. P. calcium acetate in 100 cc. warm glacial acetic acid. Add 1 cc. water and filter into a 200 cc. volumetric flask. Wash the filter with glacial acetic acid and finally make up to volume of 200 cc. with glacial acetic acid.

Determination—

Weigh into a tared container 5 gm. flour and carefully measure and add 7.5 cc. of the acetate solution. Prepare a stirring rod by tightly rolling a half sheet of 11 cm. ashless filter paper with a stirring rod. Stir the mixture into a smooth paste and insert directly into a muffle furnace maintained at a temperature of 900°C. (1650°F.) or hotter. The oven at this temperature is orange in color. At the end of 40 minutes, burning should be complete. Remove the dish, desiccate, and weigh the mixture. Blank tests should be made by evaporating 7.5 cc. to dryness at 100°C. for 40 minutes. Correct for blanks when reporting ash.

Method 5.—Weigh into a crucible or other ashing dish 4 gm. of alundum (60 mesh). Ignite the crucible and alundum in a muffle and weigh. Weigh into the tared container 2 gm. of flour. Prepare a stirring rod by tightly rolling a small triangular piece of ashless filter paper (a quarter of a piece of 11 cm. paper is very satisfactory) and with this rod carefully and thoroly mix the flour and alundum. Leave the paper rod with the sample and ignite in a muffle at 550°C. taking care that no part of the ash fuses. Care should be taken to prevent any loss of alundum by mixing and handling. Note time required to secure a white ash.

Method 4 was proposed by E. N. Frank and was successfully used by him in the Washburn-Crosby Co. laboratories.

Collaborators who had pyrometer control were asked to try all five methods. Those without pyrometer control were not asked to analyze the flours by Method 5.

Thirty-two sets of samples were sent out, and replies and results were obtained from all.

The ash results obtained on the three samples by the five methods described above are given in Tables III, IV, V, and VI.



TABLE III  
SUMMARY SHOWING PERCENTAGE OF ASH OBTAINED BY VARIOUS INVESTIGATORS  
BY FIVE METHODS ON THREE DIFFERENT SAMPLES OF FLOUR  
Sample 1—Short Patent

	Method used				
	1	2	3	4	5
	Ash, per cent				
Average	0.420	0.420	0.418	0.426	0.416
Maximum	0.450	0.433	0.434	0.520	0.430
Minimum	0.400	0.400	0.400	0.364	0.395
Range	0.050	0.033	0.034	0.156	0.035
Cooperators	20	15	19	18	4

Sample 2—Standard Patent

	Method used				
	1	2	3	4	5
	Ash, per cent				
Average	0.484	0.490	0.483	0.484	0.497
Maximum	0.514	0.520	0.500	0.620	0.505
Minimum	0.445	0.480	0.465	0.458	0.478
Range	0.069	0.040	0.035	0.162	0.027
Cooperators	22	17	21	18	10

Sample 3—First Clear

	Method used				
	1	2	3	4	5
	Ash, per cent				
Average	0.782	0.788	0.783	0.778	0.776
Maximum	0.810	0.813	0.800	0.870	0.805
Minimum	0.740	0.768	0.768	0.752	0.705
Range	0.070	0.045	0.032	0.118	0.100
Cooperators	22	17	21	20	11

The average percentage of ash found in all three samples by the five different methods was surprisingly close, the greatest difference with any sample by any method being not greater than 0.06 per cent.

This does not mean, however, that all five methods appear to be equal in value for making ash determinations. Variation in tests of as much as 0.16 of a per cent was experienced with Method 4 and large variations were likewise found from the tests made by Method 5.

Method 4 seems the most difficult to carry out. This is probably due to the fact that the ash seems to increase in amount as the intensity of heat increases.

Ashing by Methods 2 and 3 appeared to give the most dependable results of all, altho the variations here are about twice as large as recommended by the association last year as allowable tolerances between different laboratories.

Naturally, as Method 1 was peculiar to each cooperator and not used by all, the variation in results was large.

TABLE IV  
SUMMARY SHOWING PERCENTAGE OF ASH OBTAINED BY DIFFERENT INVESTIGATORS WITH  
TEMPERATURE CONTROL, BY FIVE METHODS, ON THREE DIFFERENT SAMPLES OF FLOUR  
Sample 1—Short Patent

	Method used				
	1	2	3	4	5
	Ash, per cent				
Average	0.420	0.419	0.421	0.417	0.416
Maximum	0.450	0.430	0.434	0.440	0.430
Minimum	0.400	0.400	0.398	0.364	0.395
Range	0.050	0.030	0.036	0.076	0.035
Cooperators	14	10	13	13	4

Sample 2—Standard Patent

	Method used				
	1	2	3	4	5
	Ash, per cent				
Average	0.482	0.489	0.484	0.478	0.488
Maximum	0.510	0.520	0.500	0.510	0.505
Minimum	0.445	0.480	0.465	0.458	0.478
Range	0.065	0.040	0.035	0.052	0.027
Cooperators	15	11	14	14	10

Sample 3—First Clear

	Method used				
	1	2	3	4	5
	Ash, per cent				
Average	0.781	0.788	0.783	0.772	0.776
Maximum	0.810	0.813	0.800	0.810	0.805
Minimum	0.740	0.763	0.768	0.752	0.705
Range	0.070	0.015	0.032	0.058	0.100
Cooperators	15	11	14	14	11

Owing to the small number of laboratories reporting who did not use temperature control, the comparison of results with and without the use of a pyrometer is hardly fair. In fact, on the surface, it appears from the data that there was no advantage in using a pyrometer.

Methods 2 and 3 seem to work equally well, regardless of the percentage of ash in the sample of flour under test.

Several of the collaborators voiced objection to the Bailey-Hertwig method, and as this method has worked ideally in the hands of the chairman of this committee, a number of tests were made on some of the points objected to. The time element involved and the attention necessary for preparing the sample for the muffle in the Bailey-Hertwig method, seem to be the most serious objections to its use.

It must be admitted that stirring the sample of flour with the glycerol-alcohol mixture and later igniting the alcohol before placing in the oven, is too tedious for rapid work.

Tests were made, therefore, simply adding the glycerol-alcohol mixture to the flour, letting it stand for intervals of time, noting

the rapidity with which it penetrated the mass of flour, and later the effect of such procedure on the ash results.

Carrying out the procedure as described in the above paragraph, it was found when using a 3-gm. sample and adding 1.5 cc. of the glycerol-alcohol mixture for each gram of flour ashed, that the mixture fully wetted the flour in five minutes.

TABLE V

SUMMARY SHOWING PERCENTAGE OF ASH OBTAINED BY DIFFERENT INVESTIGATORS WITHOUT TEMPERATURE CONTROL BY FIVE DIFFERENT METHODS ON THREE SAMPLES OF FLOUR

## Sample 1—Short Patent

	Method used				
	1	2	3	4	5
	Ash, per cent				
Average	0.420	0.423	0.415	0.446	.....
Maximum	0.437	0.433	0.435	0.520	.....
Minimum	0.404	0.413	0.400	0.420	.....
Range	0.033	0.020	0.035	0.100	.....
Cooperators	6	5	6	5	none

## Sample 2—Standard Patent

	Method used				
	1	2	3	4	5
	Ash, per cent				
Average	0.490	0.491	0.482	0.501	.....
Maximum	0.514	0.516	0.490	0.620	.....
Minimum	0.470	0.480	0.473	0.473	.....
Range	0.044	0.036	0.017	0.147	.....
Cooperators	7	6	7	4	none

## Sample 3—First Clear

	Method used				
	1	2	3	4	5
	Ash, per cent				
Average	0.774	0.788	0.783	0.793	.....
Maximum	0.800	0.800	0.793	0.870	.....
Minimum	0.762	0.783	0.770	0.764	.....
Range	0.038	0.017	0.023	0.106	.....
Cooperators	7	6	7	6	none

## Ashing by Modified Bailey-Hertwig Method

Ashing several flours in this manner gave results of the following order. The ash was the usual white to gray-white characteristic of the results obtained by the glycerol-alcohol procedure.

By the original Bailey-Hertwig method

.423  
.486  
.779  
.366

By the modified method

.426  
.483  
.783  
.367

It is apparent, therefore, that the Bailey-Hertwig method can be modified to eliminate almost entirely its objectionable features.



TABLE VI  
 INDIVIDUAL ASH RESULTS, A. A. C. C., SEASON 1925-26

Coop- erator	Sample No.	Method used					Remarks
		1	2	3	4	5	
Ash, per cent							
1	1	0.413	0.420	0.415	0.425	....	6 hr. 575°-580°C.
	2	0.485	0.482	0.490	0.470	....	ash medium gray.
	3	0.773	0.780	0.785	0.785	....	
2	1	....	....	....	....	....	
	2	0.486	0.495	0.485	0.486	....	Incinerated over night.
	3	0.780	0.813	0.786	0.777	....	575°C.
4	1	0.401	0.402	0.398	0.424	0.440	Method 2 ashed 5 hr.
	2	0.467	0.468	0.465	0.470	0.505	Method 3, 3 hr. and
	3	0.769	0.768	0.768	0.766	0.805	Method 4, 3½ hr. Coors crucibles 27mm. x 35mm.
5	1	0.430	0.422	0.422	0.436	0.430	Method 1, 5 hr. to 650°C. in stages.
	2	0.486	0.480	0.480	0.496	0.490	Method 2, 550°C. too low. No time saved
	3	0.784	0.786	0.790	0.776	0.796	by Method 3, rapid but chance for too much error. Method 5 has possibility.
7	1	0.400	....	0.427	0.364	0.392	
	2	0.445	....	0.455	0.430	....	
	3	0.740	....	0.760	0.680	0.705	
8	1	0.450	....	....	....	....	3½ hrs. to finish a #
	2	0.480	....	....	....	....	1200°F. (650°C.)
	3	0.795	....	....	....	....	
9	1	0.430	0.430	0.428	0.426	0.435	Temperature recom-
	2	0.490	0.488	0.484	0.492	0.480	mended too low. Near-
	3	0.790	0.792	0.784	0.778	0.790	er 1100°F. (595°C.) right. Method 5 un-
10	1	0.436	0.428	0.434	0.433	0.445	satisfactory.
	2	0.490	0.496	0.494	0.486	0.485	Method 1, 30 min.
	3	0.786	0.786	0.788	0.790	0.802	Method 2, 5 hr. Method 3, 4½ hr. Method 4, 1¼ hr. Method 5, 3 hr.
11	1	0.420	0.424	0.424	0.415	0.424	Method 1, 14 hr.
	2	0.482	0.486	0.484	0.490	0.478	1000°F. (540°C.)
	3	0.782	0.784	0.788	0.780	0.736	Method 3, 4½ hr.
12	1	0.43	0.43	0.43	0.44	0.43	Flour too dry for
	2	0.51	0.52	0.50	0.51	0.50	Methods 1 and 2.
	3	0.81	0.81	0.80	0.81	0.80	
13	1	0.400	0.400	0.416	0.397	0.395	Takes 1-4 hr. longer
	2	0.505	0.530	0.498	0.485	0.485	to ash these flours than
	3	0.780	0.783	0.780	....	0.780	Southwestern flour. Method 5 gave good ash on short time, 2 hr.
14	1	0.42	0.42	0.42	0.43	0.41	1050°F. (565°C.) to a
	2	0.48	0.48	0.48	0.48	0.48	white ash. Method 5,
	3	0.78	0.79	0.78	0.77	0.77	4 hr. at 550°C.

TABLE VI—Continued  
INDIVIDUAL ASH RESULTS, A. A. C. C., SEASON 1925-26

15	1	0.431	....	0.430	0.436	0.430	
	2	0.490	....	0.490	0.458	0.495	
	3	0.793	....	0.785	0.778	0.785	
17	1	0.416	0.414	0.420	0.420	....	Method 2, 28 hr. Method 3, ash not free of carbon at 28 hr. 575°C.
	2	0.484	0.487	0.490	0.490	....	
	3	0.786	0.780	0.790	0.785	....	
22	1	0.411	....	0.409	0.385	....	Method 3 more trouble than A. O. A. C. method, 6 hr. necessary at 575°C. Method not liked. Method 4 unsatisfactory.
	2	0.470	....	0.489	0.450	0.485	
	3	0.770	....	0.789	0.752	0.770	
3	1	....	....	....	....	....	Ashing time for Method 3, 3 hr.
	2	0.496	0.501	0.485	0.481	....	
	3	0.786	0.794	0.781	0.764	....	
6	1	0.438	0.432	0.420	0.436	....	
	2	0.496	0.495	0.473	0.500	....	
	3	0.800	0.800	0.792	0.786	....	
16	1	0.424	....	0.430	0.436	0.430	Method 2, 3½ hr.
	2	0.514	....	0.490	0.458	0.495	Method 4, 40 min.
	3	0.800	....	0.785	0.778	0.785	
18	1	0.420	0.422	0.418	0.427	....	Six hr. for all methods
	2	0.490	0.485	0.487	0.485	....	
	3	0.790	0.790	0.793	0.795	....	
19	1	0.420	0.433	0.410	....	....	Method 1, 6-7 hr.
	2	0.477	0.576	0.484	....	....	Method 2, 11 hr.
	3	0.762	0.783	0.787	....	....	Method 3, 4-5 hr. Glycerol-alcohol seemed to affect vitrosel dishes.
20	1	0.423	0.413	0.436	....	....	Method 1, 4-5 hr.
	2	0.493	0.480	0.490	....	....	Method 2, 550°C.
	3	0.773	0.783	0.787	....	....	Method 3, 575°C. Method 4, 900°C. for 40 min.
21	1	0.404	0.415	0.400	0.420	....	Method 1, over night.
	2	0.475	0.473	0.473	0.482	....	Method 2, 5 hr; Method 3, 3 hr; Method 4, 4 hr.
	3	0.776	0.781	0.770	0.770	....	
23*	1	0.42	0.425	0.412	0.440	....	
	2	0.487	0.480	0.473	0.468	....	
	3	0.797	0.800	0.812	0.676	....	
24*	1	0.435	0.442	0.443	0.452	0.420	Methods 1 and 2, same temperature of ignition, low form porcelain crucible. Method 4 gave high results.
	2	0.498	0.506	0.507	0.530	0.485	
	3	0.805	0.823	0.824	0.814	0.765	
24a*	1		0.419	....	....	....	24a data several months later.
	2		0.486	....	....	....	
	3		0.789	....	....	....	

\*Received too late to include in tables.

## Those Submitting Ash Results

1. International Milling Co., Minneapolis, Minn.	L. R. Olsen
2. U. S. D. A. Bureau of Agricultural Economics, Washington, D. C.	H. B. Dixon
3. Omaha Grain Exchange, Omaha, Neb.	M. D. Mize
4. Duluth-Superior Milling Co., Superior, Wis.	A. P. Craick
5. Wichita Flour Mills Co., Wichita, Kan.	R. B. Potts
6. Southwestern Milling Co., Kansas City, Mo.	A. R. Sasse
7. Commercial Milling Co., Detroit, Mich.	T. R. Aitken
8. Hecker Jones Jewell, New York City	C. E. Foster
9. Red Star Milling Co., Wichita, Kan.	A. A. Townner
10. Larabee Flour Mills Co., St. Joseph, Mo.	H. E. Weaver
11. National Milling Company, Toledo, Ohio	V. Shiple
12. Northwestern Consolidated Milling Co., Minneapolis, Minn.	W. J. Siaser
13. El Reno Mill & Elevator Co., El Reno, Okla.	H. F. Vaupel
14. Sperry Flour Co., Vallejo, Calif.	C. B. Kress
15. State Testing Mill, Minneapolis, Minn.	R. C. Sherwood
16. Cargill Elevator Co., Minneapolis, Minn.	W. E. Glasgow
17. Pillsbury Flour Mills Co., Minneapolis, Minn.	J. T. Flohil
18. Goerz Flour Mills Co., Newton, Kan.	R. J. Clark
19. Sherman Grain and Cotton Exchange, Sherman, Tex.	W. L. Frank
20. Ballard & Ballard, Louisville, Ky.	L. W. Whiting
21. Rodney Milling Co., Kansas City, Mo.	R. K. Durham
22. W. E. Long Co., Chicago, Ill.	A. W. Meyer
23. Ismert-Hincke Milling Co., Kansas City, Kan.	R. S. Herman
24. American Institute of Baking, Chicago, Ill.	C. B. Morison

The committee was also asked regarding the temperature at which the ashing process should be started. Inquiries were made as to whether the oven should be cold, warm, or at the designated ashing temperature when the crucibles are inserted into the oven.

The following results obtained by Mr. Fellows are of interest. Using the A.O.A.C. method, he ashed the same flours studied in the collaborative ash work, starting the tests with the muffle cold, at 200°C., at 550°C., and at 575°C. The results are given in Table VII.

TABLE VII  
Ashing by A. O. A. C. Method, Starting Tests at Various Temperatures

Sample No.	Temperature of Muffle			
	Cold*	200°C†	500°C‡	575°C§
1	.458	.458	.426	.425
2	.510	.512	.488	.486
3	.822	.818	.781	.787
4	.362	.357	.365	.358

\* Ash very black.

† Ash very dark, unsatisfactory appearance.

‡ Ash medium gray, not entirely satisfactory.

§ Ash medium gray.

The ash obtained when starting with a cold muffle and with the temperature at 200°C. was very black. The results were high.

At 550°C. the ash was medium gray, yet of a color that would cause one to wonder if the ashing was complete. Raising the temperature to 575°C. improved the appearance of the ash.



Naturally at 550°C. and 575°C. the flours flamed and there was a large volume of smoke and quite considerable draft, yet the ash results seem not to be affected.

It is absolutely impossible to start the Bailey-Hertwig method at a lower temperature than 400°C. because at lower temperature a carbonaceous mass is formed which rises up like a loaf of bread and on occasions runs over the sides of the crucible.

Sample 4 was a soft winter straight flour and the results from it would seem to indicate that there is a class distinction in the matter of ashing flours.

### Recommendations of the Committee Regarding Ash Determinations

From a consideration of the collaborative studies on hand at this time, the following methods of making ash determinations on flour, mill feeds, and wheat are recommended for adoption by the association.

Wheat and bran should be ground so that they pass a sieve with circular perforations  $1/25$  (mm.) in diameter and thoroly mixed.

#### Method A

**Determination.**—Rapidly weigh 3-5 gm. of the well mixed sample into a shallow, relatively broad ashing dish which has been ignited, cooled in a desiccator, and weighed soon after reaching room temperature. Incinerate in a furnace at just below dull red heat until the ash becomes fluffy and white or gray-white in color or until no further loss in weight occurs. Usually a temperature of 550°C. or 1022°F. will be sufficient. At times, however, a somewhat higher temperature (not over 600°C.) will be necessary. Cool in a desiccator and weigh soon after the crucibles have reached room temperature. Calculate to per cent ash.

#### Method B. Bailey-Hertwig

**Determination.**—Rapidly weigh 3-5 gm. of the well mixed sample into a shallow and relatively broad ashing dish which has been previously ignited, cooled in a desiccator, and weighed soon after reaching room temperature. To the sample in the dish add  $1\frac{1}{2}$  cc. of glycerol-alcohol solution (made from equal parts of glycerol and alcohol) for each gram of sample to be ashed. Place the crucibles in the furnace at a temperature of 575°C. and heat until the ash becomes fluffy white or gray-white. Place in a desiccator and weigh soon after the crucibles have reached room temper-

ature. If technical glycerol has been used, a blank determination is necessary. Calculate to per cent ash.

### Moisture Determinations

The flour moisture problem seems to be as difficult to solve as ever. Early in the year, it appeared that a solution was close at hand regarding what method and what procedure would be considered official by the Food and Drug officials of the U. S. Department of Agriculture at a conference held at Washington at which members of the Millers National Federation, members of the United States Bureau of Chemistry, and others interested in flour moisture problems were present, methods for making moisture determinations in flour were discussed.

It was brought out that neither the Food Control officials nor the Millers National Federation desired to use the old water-oven method for making moisture tests on flour, because the errors attending the use of this method were too great for uniformity of application.

It was further agreed that the vacuum-oven method, even tho it is subject to error, would be finally agreed upon.

A vigorous debate ensued over the differential that would be used to interpret the water-oven tests in terms of the vacuum-oven tests. The Millers National representatives requested that the expression of flour moisture be made 13.5% on the water-oven basis and 15% on the vacuum-oven basis.

A decision has been reached within the Bureau of Chemistry, and their recommendations have been forwarded to the Director of Regulatory Work for approval.

As it was evident that the Bureau of Chemistry and the Millers National Federation are in agreement as to the method that will be used for making moisture determinations on flour, i. e., the vacuum-oven method, no additional work was carried on this year with this type of method, it being assumed from a study of G. E. Shuey's collaborative moisture studies published in *Cereal Chemistry*, Vol. II, No. 3, page 318; and from G. E. Spencer's reports to the A. O. A. C. for 1924 and 1925, that an acceptable air-oven substitute for the vacuum-oven test was ready whenever conditions were ready for its use.

It seemed idle for the committee to work on methods which designated temperatures between those recommended for the operation of the water-oven method (98°-100°C.) and the substitute vacuum-oven method (130°C.).

## Recommendations of the Committee Regarding Moisture Determinations

For the present, therefore, the committee recommends that the vacuum-oven method and the Spencer Modification be adopted by the association as tentative methods.

### I. Vacuum Method

#### Apparatus

(a) **Metal dish.**—Diameter about 55 mm., height about 15 mm., provided with an inverted slip-in cover fitting tightly on inside.

(b) **Air-tight desiccator.**—Should contain reignited quick lime or calcium carbide.

(c) **Vacuum oven.**—Should be connected with a pump capable of maintaining a partial vacuum in the oven with a pressure equivalent to 25 mm. or less of mercury and provided with a thermometer passing into the oven in such a way that the bulb is near the samples. A concentrated sulfuric acid gas drying bottle is connected with the oven for admitting dry air for releasing the vacuum.

(d) **Mercury manometer.**—Used to indicate the pressure of the partial vacuum.

#### Determination

Weigh accurately about 2 grams of the well mixed sample in a covered dish that previously has been dried at 98°-100°C., cooled in the desiccator, and weighed soon after attaining room temperature. Loosen the cover (do not remove) and heat at 98°-100°C. to constant weight (approximately 5 hours) in a partial vacuum having a pressure equivalent to 25 mm. or less of mercury. Admit dry air into the oven to bring to atmospheric pressure. Immediately tighten the cover on the dish, transfer to the desiccator, and weigh soon after room temperature is attained. Report the flour residue as total solids and the loss in weight as moisture (indirect method).

### II. Routine Air-Oven Method

(This method gives results closely approximating those by the vacuum method.)

#### Apparatus

(a) **Metal dish and desiccator.**—As described under I.—the Vacuum Method.

(b) **Oven.**—Should be capable of being maintained at approximately 130°C. ( $\pm 3^\circ$ ) and provided with an opening for ventilation.

(c) **Thermometer.**—To be placed with its bulb near the samples.



### Determination

Weigh accurately approximately 2 grams of the well-mixed sample in a covered dish that has been dried previously at approximately 130°C. ( $\pm 3^\circ$ ), cooled in a desiccator, and weighed soon after attaining room temperature. Uncover the sample and dry the dish, cover, and contents in the oven at approximately 130°C. ( $\pm 3^\circ$ ), for one hour. Cover the dish while still in the oven, transfer to the desiccator, and weigh soon after room temperature is attained. Report the flour residue as total solids and the loss in weight as moisture (indirect method).

### Uniform Moisture Basis for Mill Feeds

During the year the question was agitated of reporting feed analyses on a uniform moisture basis. In collaboration with the committee chairman, R. J. Clark canvassed the thought of such organizations as the American Association of Official Agricultural Chemists, the Millers National Federation, and the Association of Feed Control Officials.

Objection to this idea was voiced by the Association of Official Agricultural Chemists, as well as by the Association of Feed Control Officials.

To quote in part a letter to Mr. Clark from F. D. Fuller, president of the Association of Feed Control Officials will convey their state of mind on this subject.

"The various legislatures enacting the feed laws of the United States contemplated that tags attached to the packages of feed should furnish the customer with correct information regarding the feed when delivered into his hands and not what the analysis would be when the results were calculated on a basis of 13.50% moisture, the analysis of every feed product would necessarily have to be reported in like manner, as it would not be just and proper to discriminate in favor of the wheat millers. Therefore, as president of the Association of Feed Control Officials of the United States, I can not lend my personal assistance or that of the association in favoring the rendering of reports of analysis on any specified moisture basis and I am sure that every member of our association would support me in this decision.

"I regret my inability to co-operate with you on this subject."

Sydney Anderson, of the Millers National Federation, stated, also, that it would be preferable to avoid bringing this matter to the attention of Feed Control officials at this time.

### Brown-Duvel Moisture Tester

Requests were made to the committee chairman that a study be made of the Brown-Duvel moisture tester, especially with a view toward perfecting this device and the technic for its operation so that more reliable results would be obtained.

At the time these requests were received, it was known to the committee chairman that the Department of Agriculture had completed just such a study and that a full report of their findings was then in press. Since, Bulletin 1375, entitled, "The Brown-Duvel Moisture Tester and How to Operate It," has come to hand. In this manuscript the full and latest directions are given for making moisture tests by other apparatus, as well as its recommendation for standardizing the equipment, etc. As your chairman is senior author of this publication, any questions that may arise as to its operation will be considered if it is possible to do so.

In the 1922 Book of Approved and Tentative Methods of Analysis, under "Moisture in whole grain," it is recommended that the Brown-Duvel moisture tester be equipped with a Jones-Baker device to prevent superheating and to bring about more reliable results.

Frequent inquiries have come to the chairman of the methods committee seeking information on the utility of this device, and in order to answer the questions more intelligently tests were made, operating the Brown-Duvel tester in the approved manner with and without the addition of the Jones-Baker device.

As far as could be ascertained, the Jones-Baker device gave no more accurate results or results in closer duplicate tests than when no bulb cages were used.

The grain from the tests made without the thermometer bulb cages was practically of the same color as that from tests made with cages. No evidence was found of fluctuation in the mercury column when the tests were made without the cages.

The heating time, cooling time, and end temperature were practically the same for the comparative tests with and without the bulb cages.

If the Brown-Duvel testers are operated outside of the standard conditions prescribed for the test, the cages will not help, as tests made when they were used showed just as wide variations as those made without the bulb cages.

The experimental data on this point are shown in Table VIII.

TABLE VIII

## THERMOMETER BULB CAGES VS. NO CAGES

Summarized results of 3 series of 24 moisture tests each on the same sample of wheat, in which 12 tests with the cages were checked against 12 tests without the cages in each series. The results show that the cages have no appreciable effect on either the accuracy of or range in moisture test results in testing with the standard moisture tester.

		Average		Maximum		Minimum		Range		Average variation from standard	
		Cages	No cages	Cages	No cages	Cages	No cages	Cages	No cages	Cages	No cages
Heating time (min.)	Series I										
	Standard	16.5	17.1	17.3	17.5	16.5	16.8	.8	.8	-0.6	
	Series II										
	2 min. fast	15.2	15.2	15.5	15.8	15	14.8	.5	1	-1.9	-1.9
Cooling time (min.)	Series III										
	4 min. fast	13.2	13.2	13.5	13.5	12.8	13	.8	.5	-3.9	-3.9
	Series I										
	Standard	20	19.3	21	20	19	18	2	2	.8	
End temperature (deg.)	Series II										
	2 min. fast	20.6	20.3	21.5	21	18.3	19	3.3	2	1.3	1.0
	Series III										
	4 min. fast	22.3	22.5	24	23.8	20	20	4	3.8	3.0	3.3
Per cent moisture	Series I										
	Standard	189.7	190	190	192	189	189	1	3	-0.3	
	Series II										
	2 min. fast	191.7	191.5	193	193	189	190	4	3	1.7	1.5
	Series III										
	4 min. fast	195	195.6	198	198	192	192	6	6	5.0	5.6
	Series I										
	Standard	12.34	12.38	12.5	12.5	12.2	12.3	0.3	0.2	-0.04	
	Series II										
	2 min. fast	12.52	12.48	12.7	12.7	12.3	12.3	0.4	0.4	0.14	0.1
	Series III										
	4 min. fast	12.75	12.74	13.1	13.0	12.4	12.5	0.7	0.5	0.37	0.36

## Flour Sampling Studies

During the year this organization was asked to co-operate with the associate referee on cereal products of the A. O. A. C. regarding the development of a method for sampling flour.

In conjunction with L. A. Olsen, M. A. Gray, and C. B. Morison, H. Runkle, inspector in charge of the Minneapolis Food and Drug Laboratory of the U. S. Bureau of Chemistry, canvassed various individuals and organizations regarding technic for such a method, and after considerable thought on the subject the following tentative method was adopted for study. Mr. Runkle has already presented this method to the A. O. A. C. at their October, 1925, meeting, where it was accepted as a tentative method of study for the following year. The method as proposed is as follows:

## Directions for Sampling Flour for Chemical Analysis

Sample a number of sacks equivalent to the square root of the number in the lot, but not less than ten, i. e., ten from 100 or less, fifteen from 225, twenty from 400, etc.



Select the sacks to be sampled, according to their exposure in the ratio of four from the most exposed, three from the next least exposed, two from the next, two from the next, and one from the least exposed portion of the lots.

From each sack to be sampled, draw a core from one corner of the top diagonally to the center of the sack by means of a cylindrical, pointed, polished steel trier, one-half inch in diameter, with a slit of at least one-third the circumference. Draw a second core from the other top corner to one-half the distance to the center of the sack.

Deliver the two cores at once to a clean, dry, air-tight container which has stood open for a few minutes near the lot of flour to be sampled, and seal immediately. Use a separate container for each sack sampled. Either of the following containers may be used: (1) one pint mason jar, (2) a rubber pouch which can be tied or sealed to exclude moisture or air, (3) a tin can or box with a moisture- and air-tight friction top.

Before opening the sample for analysis, alternately invert and roll each container twenty-five times, or more if necessary to secure an homogeneous mixture. Avoid excessive temperatures and humidities when opening for analysis. Keep the sample tightly sealed at all other times.

For such supplemental determinations as net weight, uniformity, and baking tests, samples may be increased in number, increased in quantity, or combined to suit the requirements of the analyst if the principles laid down above are followed.

#### **Recommendations of the Committee Regarding Flour Sampling Methods**

It was recommended that this method be given study during the coming year.

#### **Collaborative Hydrogen-ion Studies**

H. E. Weaver conducted the collaborative work on this test, and the results of his tests are shown in Table VIII.

#### **Recommendations of the Committee Regarding Hydrogen-ion Determinations**

Mr. Weaver recommends that these studies be continued another year and that 10 grams of flour be used with 100 cc. of water extracting for 30 minutes at 25°C. The type of H. electrode and calomel electrode to be optional with the operator.

TABLE IX

DETAILS OF METHODS AND RESULTS OF DETERMINATION OF THE HYDROGEN-ION CONCENTRATION OF THREE FLOUR SAMPLES

Collaborator No.	Weight of flour per 100 cc. of water	Time of extraction	Temperature of extraction	Concentration of KCl in calomel electrode	Type of hydrogen electrode	H-ion concentration as pH		
						Sample No.		
	gm.	min.				A	B	C
1	*	60	Room	*	Hildebrand	5.56	5.80	6.34
2	10	60	25°C.	Saturated	Hildebrand	5.67	5.87	6.20
3	20	60	25°C.	Normal	Bailey	5.85	5.91	6.20
4	15	25	Room	Saturated	Hildebrand	5.89	6.15	6.33
5	10	30	25°C.	Saturated	Hildebrand	5.66	6.17	6.46
6	10	120	25°C.	Saturated	Hildebrand	5.68	5.82	6.17
7	10	30	3°C.	Saturated	Bailey	5.54	5.86	6.26
8	10	30	Room	Saturated	Bailey	5.60	6.00	6.34
9	10	60	25°C.	Saturated	Bailey	5.51	5.80	6.24
10	10	60	25°C.	Saturated	Bailey	5.54	5.81	6.32

\*No report

## ADDRESS OF THE PRESIDENT

R. J. CLARK

Goerz Flour Mills Co., Newton, Kan.

(Given at the Convention, June 7, 1926)

We are assembled in the twelfth annual convention of this association. Twelve months have slipped away since last we gathered to renew friendships, exchange experiences, and hear the wonders possible through research. These months have been crowded to overflowing with work. Notable achievements have taken place in the affairs of our association. Many of these have been given you through the medium of our News Letters. Many more will be revealed as the officers and committees of this convention make their reports. On the whole we have prospered during the year which has just closed.

Our association stands higher numerically, financially, and in the estimation of allied organizations than it did one year ago. It has rendered service to its members, and valuable assistance to non-members. The keynote of the last year has been team work, both in service and efficiency. No petty jealousies have marred the co-operation of committee chairmen. Your vice-president, secretary, and other officers have worked together as one man with explicit faith in one another. It is thus indeed pleasant to close the year with such memories, and I wish in this inadequate way to express my sincere appreciation of the support of the association members and the earnest work of the officers and committees. Turning from the past let us profit by our experiences and face the future with confidence that our success will be even greater in the year to come. Many problems are before us for consideration.

This association needs first of all a stabilizing balance of power which will render more permanent not only its policies but also its work and influence.

As our form of organization now operates, all the officers and committees may be changed by the annual election and a completely new group of officials placed in charge of association affairs. Fortunately, such a revolution has not taken place because some officer has always been re-elected. The loop hole is present, however; and, if fate took charge, the result might be disastrous. It is plainly evident that policies of management should not be changed each year. If a program of advance is entered upon, it should be carried to completion, even tho several administrations come and go during the time required to carry out the program. Rotation in office is very beneficial, stimulating initiative and progress; but it undermines and tears down when it threatens the fundamental principles of our organization.

As a remedy for this condition and in order to maintain a continuity of purpose and policies, I suggest that the executive committee be made up of the ex-presidents of our association. In this way, even tho a complete new group of officers were elected, no important policies could be changed until the executive committee gave its consent. The members of this committee, vested with the highest authority of the association, having been at one time in an executive position, would be familiar with the established customs and could hold in check any possible radical changes.

There are now in existence five local clubs, made up of cereal chemists in various parts of the country. Most of these club members are also association members. These clubs, because of their frequent meetings, stimulate interest in cereal problems and are proving a real benefit to their members. They can be made a material aid to our association, because (1) new members can be recruited through their influence; (2) the association can secure aid on important questions because of the frequent local club meetings. The organization of these clubs proves a healthy condition in the interest of our association members. These clubs should be recognized officially by our national organization.

Many forms of recognition have been proposed and discussed. One of the most plausible appears at present to be one in which the local club is made a section of the A. A. C. C. A charter could be granted to the club, provided all the club officers and at least 75 per cent of its members were also A. A. C. C. members. By thus recognizing the smaller club organization, the committee



work of our national body could be more effectively performed, because data could be collected by regional sections, and questions thrashed out first in small units before burdening our national conventions with minor issues.

The most important test made today in a cereal laboratory is the baking test, and yet it is the one in the performance of which we, as chemists, cannot agree. Some chemists bake a nice loaf to decorate the dinner table of some member of the firm, some bake as nearly like the commercial baker as is possible, while still others try to test the flour. We are far apart on the purpose or the goal for which we are striving. How can we hope to map out the course when we do not agree on the port of destination. This is an important question, so important that an association committee has been given the power to investigate and work out a solution. Nine out of ten millers who employ chemists today bin wheat on its protein content, and yet that wheat is supposed to deliver a uniform baking flour. Is it not far more reasonable and logical to bin wheat on its baking ability, since it has been proved in research that two flours of the same protein content may have different baking abilities? How many baking methods in use at the present time are accurate enough to detect extremely slight baking qualities? This is a matter of standardization. If we cannot agree among ourselves, how can we hope to convince our managements or the public that cereal chemistry is a necessity and not a luxury. I therefore implore you to give serious consideration during this convention to the report of our baking committee. Let this convention decide the following questions: (1) Is baking the most important test we perform? (2) What is the object for which we should bake? (3) What are the means by which this object may be attained or what is the procedure?

It has been four years since our book of methods was published. Each convention has adopted changes and recommended new procedures. Our book is therefore in serious need of revision. I suggest that the chairman of our methods committee be empowered by this assembly to revise—bring down to date—our collection of chemical methods; and publish at the expense of the treasury as many copies of the new book as our convention may stipulate.

As we all know, when bran and shorts are manufactured, they contain an amount of moisture which may vary between wide limits; but, roughly speaking, the moisture content approximates 13.50 per cent on an air-oven determination. In making an analysis on feeds it is the custom to report crude fiber, fat, protein, ash, etc.,

on a moisture basis as found. Now, a mill may meet the state requirements with ease, if the analysis is made upon the fresh feed. It takes some time for an inspector's sample to reach an official laboratory and in transit this sample dries out in some cases 2 or 3 per cent. An analysis made on the dryer sample does not reveal the same figures as did the first analysis on the fresh material; and the mill may be called to account, if the last analysis failed to meet the state laws. Much trouble, argument, and in some cases expense could be saved if all reports on feed were rendered to an arbitrary moisture content. Agreement would be far easier. It therefore seems plausible that this question should at this time receive our consideration.

This association stands for advancement in cereal work and should strive to promote such endeavor in every way possible. We have presented in our conventions many fine papers which are based on careful and painstaking research. Much work is necessary both in their writing and in their presentation. We have no adequate way of rewarding a member for meritorious work except a hand shake or a slap on the shoulder. These are much to be desired, but too often even these manifestations of appreciation are forgotten. I would suggest that a sufficient amount of the interest obtained from the money our treasurer has invested be used to purchase two gold disks to be properly inscribed as medals. One of these medals could be awarded for the best paper presented on the industrial application of cereal chemistry; the other for the best paper on fundamental research in cereal chemistry. This material recognition of merit would require the appointment of a committee to formulate rules for the contest and act as judges of the papers presented. The contest could close long enough before our annual convention to allow the judges sufficient time to read the manuscripts entered, decide upon the winners, and arrange for the presentation of the medals during the convention.

This association is only eleven years of age. New problems of management are constantly presenting themselves. A member is selected as chairman of a committee and performs his duties to the best of his ability. He may make some mistakes because it is pioneer work to him. He has never passed through such experiences before. His successor may make the same mistakes, which are obviously not the fault of the members because the work entrusted to them is new. It would increase the efficiency of the association work if a brief outline of the duties of each committee

chairman were drawn up and collected into a condensed leaflet. Such a guide or program should be written by the chairmen themselves. In a few years, after several chairmen have recorded the duties of their respective offices, this leaflet would grow to be a ritual which would be found extremely valuable to officers and members alike. In this way committee work and association machinery would work smoothly, more efficiently, and fewer mistakes would result.

During the last year no little unrest has been felt by our members, especially those connected with flour mills. Frequently this unrest has grown to discouragement. Our employment committee has been swamped not only with men seeking employment but also men seeking a change in location. For several years there has been a common saying among chemists that no chemist ever became rich. There appears to have been a tendency to look down upon chemistry and chemists as tho they occupied the lowest level of human endeavor. This sentiment has been common to both the cereal chemist and his employer and has grown to an extreme proportion during the last year. It has been a year of liquidation and business slackness so far as the millers were concerned. Why has the laboratory always been the first department to be reduced? Why has the chemist always been among the first to have his wages cut in such a depression? Only one conclusion is logical. The value of cereal chemistry is not appreciated, or, to use a common phrase, the laboratory has not been put over. It is true we are pioneers in our field.

Upon whom can we place the blame for this lack of scientific appreciation in industry? Only two people can logically be indicted, the chemist himself and his employer. Let us first consider the cereal chemist himself.

All too many cereal chemists believe when they apparently make no progress that their boss is to blame. This is only human nature. They fail to turn the spot light of self-analysis upon themselves; and, by the principles of psychology, determine if they are fully prepared for that raise or if they have proved to their managements that they are an asset, not a liability. They see no future. Naturally there is no future where vision is dead. The smaller men point to the larger paid men in the field and say how lucky this one or that one is. Luck may have played a small part in the success of the higher paid men; but back of it all there has in nearly every case been hard conscientious work in the laboratory,



as well as brain work in studying where and how chemical principles and chemical language could be translated into the dollars and cents language of the business man.

There are fundamentals in every field of endeavor. Two plus two equals four is a fundamental of arithmetic. Six per cent on \$100 for one year equals \$6 is a fundamental of banking. Just so religion, politics, art, and business have fundamental principles. A fundamental of the business man is profit, or money made on an investment. Without profit a business fails. There are fundamentals in cereal chemistry, as quality of wheat and quality of flour. Not always is the lowest priced wheat or the lowest priced flour the cheapest wheat or flour to buy. If the cereal chemist is familiar with the milling yield, flour quality, absorption, fermentation possibilities and gas retention in doughs, he can probably advise the management that the higher priced wheat or flour is the cheapest in the long run, and back his advice with figures.

Now the chemist will get the attention of the management, because he has translated his chemical fundamentals over into business fundamentals and is talking to his employer not in technical terms (foreign to the business layman) but in terms easily understood and applied. What does the head of a firm care or in many cases know about protein and ash? They are as full of meaning to him as the fourth dimension and the Einstein theory are to the average chemist. If the chemist, however, can use ash and protein to distinguish between a patent and a clear, and by knowing that a clear will give the baking results desired advise its use, obviously a saving will result in the price. This again is translation of chemical into business fundamentals. But still there are chemists who can speak only the chemical language.

Next let us consider the employer. He has in his organization a highly trained technical man. Many times he does not realize what this man knows. He does not know what the chemist should do. Can he expect his cereal chemist to advise him about the coal he purchases, the oil he uses, or the soap with which he washes his hands? Certainly, if he has a real chemist he can expect to receive such information. Believing that all the chemists should do is to check the mill, he settles many questions without the advice of his technical employee. Thus his laboratory becomes merely a control laboratory, performing only a routine amount of work, and fails to deliver its full potential power. All the chemists in this convention might miss a barrel or two of poor flour if the miller deliberately wanted to spoil the flour. Obviously then, beyond

expecting a general report upon a day's run, a mill manager should not expect half-hour analyses on the flour. Nor should a bakery manager require an analysis on each barrel of malt, on every can of eggs, or on each tub of shortening. The important object is knowing how much can be saved in using one brand over another or how the overhead may be reduced, in short, reduce routine and increase research or the solution of problems. The management may even purposely ignore the laboratory on vital questions altho this does not seem probable. Such are a few of the conditions under which members of our association are working and which may be causing this dissatisfied feeling.

What is the remedy? We cannot change such a condition except by a long process. The American Chemical Society some time ago instituted a general educational program. I wish to recommend that this association work in co-operation with the A. C. S. to the fullest extent. I suggest that some of the able men in our field be appointed to write articles for the enlightenment of (1) we chemists, and (2) our employers. Articles dealing on what a management should reasonably expect from its chemist, should be sent in pamphlet form direct to the employer of every chemist in this organization. Articles instructing the chemist not only on how to translate protein, ash, and moisture into dollars and cents, but also what can be expected from him, should be placed in the hands of every A. A. C. C. member. In this way we may in time reach that utopian condition in which the cereal laboratory is the last department of the organization to be reduced when depression approaches.

In conclusion, I wish to present to this convention for its consideration the following recommendations:

(1) That the executive committee be made up of ex-presidents so that association policies may be made more permanent.

(2) That charters be granted the various local cereal clubs and that they be made sections of the A. A. C. C., provided that all the club officers and at least 75 per cent of the club members are also association members.

(3) That this convention do its utmost to decide: (1) whether or not baking is the most important test performed in a cereal laboratory. (2) What is the object for which the test is performed. (3) What is the procedure by which this object may be attained.

(4) That our methods committee be empowered to revise and publish a new book of methods.

(5) That some moisture basis be determined upon which to render all feed reports.

(6) That gold medals be offered by the association for the best papers presented in its annual conventions; one medal for the best paper on the industrial application of cereal chemistry and one for the best paper on fundamental research in cereal chemistry.

(7) That the duties of each committee be outlined as seen by the committee chairmen and this material collected into a condensed form which in time might resemble a ritual or guide book.

(8) That a broad educational program be inaugurated which will endeavor to point out to the employer what can be expected of his chemist and to the chemist what he should do to render more efficient service.

#### **MINUTES OF TWELFTH ANNUAL CONVENTION OF THE AMERICAN ASSOCIATION OF CEREAL CHEMISTS**

By R. K. DURHAM, Secretary-Treasurer  
The Shirley-Savoy Hotel, Denver, Colo.

June 7 to 11, 1926

Monday, June 7

Meeting called to order at 10:30 a. m. at Shirley-Savoy Hotel by President R. Clark.

Reading of communications by the Secretary.

Announcements by President Clark.

Address by Frank Witter, Past President of A. O. M.

Appointment of Committees:

Nominating Committee: R. W. Mitchell, Chairman; T. G. Fletcher, M. A. Gray.

Resolutions Committee: R. C. Sherwood, Chairman; A. A. Schaal; C. B. Kress.

Auditing Committee: R. W. Bohn, Chairman; L. D. Whiting; E. J. Rosse.

Address by President Clark.

Moved by M. A. Gray that committee be appointed to draft a resolution in appreciation of the good work done by Mr. Harry Snyder. Seconded and carried.

President designated resolutions committee to take care of this.

Meeting adjourned by motion at 11:30 a. m.

Tuesday, June 8

Meeting called to order at 9:00 a. m. at Shirley-Savoy Hotel by President Clark.

Announcements.

Paper—"Report of Baking Committee," by L. A. Fitz.

Paper—"Some Factors Influencing the Experimental Baking Test," by R. S. Herman and Victor M. Hart.

Paper—"The Relation of the Crude Protein Content of Flour to Loaf Volume," by C. H. Bailey and R. C. Sherwood.

Paper—"The Problem of Test Bakes, with a Discussion of Certain of Their Chemical and Physical Aspects," by F. L. Dunlap.

Paper—"The Commercial Protein Test on Wheat," by W. O. Whitcomb.

Meeting adjourned at 12:00 noon.



Meeting called to order at 2:10 p. m. by President Clark.

Paper—"Leavening Agents for Self-rising Flour," by Paul Logue and Irene Ranker.

Round Table Discussion of Laboratory Experimental Baking, led by a paper entitled "Problem of Standard Experimental Test" by M. J. Blish.

A very heated discussion followed on the question "Why do we bake and is baking the most important test?"

The discussion narrowed down to "What is meant by quality, strength, and stability of flour?"

Moved by Blish that definitions for quality, strength, and stability be left to the baking committee. Seconded.

Motion withdrawn.

Moved by Fitz that baking committee formulate and submit definitions of the terms "quality, strength, and stability" to this convention at a later date. Seconded, carried.

Moved that the following be adopted as a tentative outline. Seconded. Why do we bake?

To determine quality.

1 Strength

a—stability

b—potentialities

1—loaf volume

2—absorption

2 Inside characteristics

a—color

b—texture

c—grain

3 Outside characteristics

a—bloom

b—break

c—symmetry

d—crust

Moved and seconded as an amendment that 2 and 3 be stricken out. Amendment lost.

Original motion carried. Meeting adjourned at 5:12 p. m.

Wednesday, June 9

Meeting called to order by President Clark at Shirley-Savoy Hotel at 9:20 a. m.

Announcements.

Report of methods committee by D. A. Coleman, Chairman.

Moved by Mangels that that portion of committee report referring to protein determination be accepted. Seconded.

Mize amends motion to strike out the word "zinc", motion lost for want of second.

Original motion carried.

Moved by Fletcher that committee recommendation on ash determination be accepted. Seconded and carried.

Moved by Bailey that committee recommendation on moisture be modified to read "at 100°C." instead of "at temperature of boiling water." Seconded, carried.

Moved by Alcock that paragraph beginning with "wheat and bran, etc." be deleted. Seconded, carried.

Thompson moves that Spencer method be modified to read "Cool to room temperature" instead of "for twenty minutes." Seconded, carried.

Mangels moved the recommendation on moisture as amended be accepted. Seconded, carried.

Thompson moved this association go on record as favoring the adoption of a standard moisture to which feed analyses be calculated. Seconded.

Moved by Gray that motion be amended to read that the association go on record as favoring reporting of analysis of mill feed as found and include moisture analysis. Seconded.

Amendment withdrawn.

Original motion lost.

Moved by Gray that this association go on record as favoring reporting analysis of mill feed as found and include moisture analysis. Seconded, carried.

Moved by Fitz that recommendation of methods committee for sampling flour be accepted. Seconded, carried.

Moved by Gray that this method be applied to feeds where applicable as well as to flour. Seconded, carried.

Moved by Morison that the association extend to Dr. Coleman a vote of thanks for his work as chairman of the Methods committee. Seconded, carried.

Report of sub-committee on hydrogen-ion concentration by H. E. Weaver.

Moved by Thompson that recommendations for determining hydrogen-ion concentration as proposed by Weaver be adopted tentatively. Seconded, carried.

Moved by Thompson that methods committee take up colorometric method of hydrogen-ion concentration for collaborative study during the next year. Seconded, carried.

Meeting adjourned at 12:10 by motion.

Thursday, June 10

Meeting called to order at Shirley-Savoy Hotel by President Clark, at 9:00 a. m.

Announcements.

Moved by Wood that minutes of 1925 convention as printed in the July, 1925, number of Cereal Chemistry be adopted. Seconded, carried.

Reports of officers.

Report of Secretary-Treasurer, R. K. Durham.

### **Annual Report of the Secretary-Treasurer of the American Association of Cereal Chemists**

**May 28, 1926**

By R. K. DURHAM

The American Association of Cereal Chemists has just passed its eleventh birthday. Each year has been one of growth in membership and recognition. Growth has not come steadily, but rather with increasing momentum. The convention in Chicago in 1923 was, without a doubt, the association's greatest meeting since its organization. With that meeting came the amalgamation with the American Society of Milling and Baking Technology and the founding of the new publication Cereal Chemistry. This journal has been the medium through which the association has secured international recognition. It goes to members and subscribers on every continent. It brings us revenue, it brings us new members, and it brings us the honor of having been first and alone in the field with a technical publication containing the results of research in the realm of the greatest of all foodstuffs, cereal grains.

The charter members of this organization were all flour mill chemists located in the southwest. Our present membership embraces chemists in a wide variety of activities. Flour maturing and bleaching products, phosphates, bread making, biscuit and cracker making, milk and milk products, shortening, yeast, mixed feeds, breakfast foods, government, state and commercial laboratories, grain inspection departments, colleges, universities, and experiment stations are all represented. In fact, flour mill chemists make up only about half of our present membership.

During the last year 65 members have been added to the list. The secretary has names of about fifty chemists who are eligible but for some reason cannot be induced to file application for membership. There are no doubt several hundred others who are eligible. We now have almost 300 members. It should not be too much to expect this list to grow to 500 in the very near future.

The secretary's duties are becoming heavy and very much diversified. He receives communications in several different languages. He is called upon to answer questions on methods of analysis, to settle the present chaotic condition of the moisture standard for flour, to supply membership lists, etc. A manufacturer of cod liver oil asks for data on phosphorus content of wheat and yellow corn. Data on conventions, i. e., time and place of meeting, method of selecting city, probable attendance, etc., have been requested by nearly every large city in the United States and Canada.

The secretary must watch the trade journals for news items and employ various other methods of locating members who have moved and failed to send a new address.

Sixty-five new members were added this year and 14 were dropped for various reasons or have resigned. On June 1, 1925, we had 207 active and associate members, 36 corporation members, and 1 honorary member, a total of 244 members. We now have 258 active and associate members, 34 corporation members, and 1 honorary, a total of 293. This is an increase of 49 members, or approximately 20 per cent.

The following report of E. R. Burt and Company, Certified Public Accountants, is submitted as treasurer's report. This audit was made in compliance with a motion passed at the 1925 convention.

R. K. Durham, Esq.,  
Secretary-Treasurer,  
American Association of Cereal Chemists,  
Kansas City, Mo.,  
Dear Sir:

Pursuant to your instructions we have made an examination of the Receipts and Disbursements of the American Association of Cereal Chemists as shown by the books, for the year ended May 28, 1926, and submit herewith our report thereon together with the attached statements, which are briefly described for identification as follows:

Exhibit

A Financial statement as at May 28, 1926

B Receipts and disbursements for the year ended May 28, 1926

Comments

We examined the vouchers and checked the distribution of the disbursements. Receipts were accepted as shown by the books.

Cash in bank was reconciled into agreement with a certificate received from the depository. The Imprest fund was not verified by actual count, as it is not handled in Kansas City.

The investment in shares of the Benefit Building and Loan Association of Kansas City was evidenced by the following certificates which bear interest at the rate of 6 per cent per annum.

Certificate Nos.	Shares	Cost per share	Total
2189	8	\$250.00	\$2,000.00
2190	1	250.00	250.00
2191	1	250.00	250.00
2328	2	250.00	500.00

Accounts receivable, loans and prepaid dues, shown in detail on Exhibit "A", were not subjected to individual verification by us.



While we have capitalized the expenditures made for cabinets and cases during the current year, no attempt was made to trace any other fixed assets which the association may own, as none are shown on the books.

WE HEREBY CERTIFY that, subject to the foregoing comments, we are of the opinion that the attached statements correctly set forth the financial position of the American Association of Cereal Chemists as at May 28, 1926, and the receipts and disbursements for the year ended on that date.

Respectfully submitted,  
Edward R. Burt and Co.,  
Certified Public Accountants.

June 2, 1926

American Association of Cereal Chemists

EXHIBIT "A"

Financial Statement as at May 28, 1926

ASSETS

Imprest fund, Minneapolis .....	\$ 100.00
Cash in bank .....	7.60
Building and loan stock .....	3,000.00
Cabinets and cases .....	62.11
Accounts receivable—Advertising	
La Motte Chemical Company .....	\$ 45.00
Central Scientific Company .....	18.00
Longmans, Green and Company .....	10.00
	<hr/>
Total accounts receivable .....	73.00
	<hr/>
TOTAL ASSETS .....	\$3,242.71

LIABILITIES

Loan—Stanford Research .....	\$200.00
Prepaid dues	
Clemens Auer .....	\$ 5.00
F. A. Collatz .....	5.00
W. W. Hatton .....	10.00
S. F. Poindexter .....	5.00
	<hr/>
Total prepaid dues .....	25.00
	<hr/>
Total liabilities .....	225.00
	<hr/>
NET WORTH at May 28, 1926 .....	\$3,017.71

American Association of Cereal Chemists

EXHIBIT "B"

Statement of Receipts and Disbursements for the year ended May 28, 1926

Receipts

Magazine subscriptions and sustaining membership dues.....	\$ 2,188.57
American Association of Cereal Chemists dues .....	584.00
Advertising .....	1,398.55
Reprints, extra copies, etc. ....	262.59

Total receipts .....

\$4,433.71

Disbursements for Expenses

Stationery, postage, printing, and supplies.....	\$ 413.04
Stenographic expense .....	259.59
Printing, proofing, etc., of magazine .....	2,380.99
Repayment of expenses to R. J. Clark .....	115.07
Repayment of expenses to C. G. Ferrari .....	209.60
1925 Convention expenses paid to C. H. Bailey .....	39.55
1925 Convention programs and placards .....	38.60
Present for M. J. Blish .....	25.00

Retainer fee to R. K. Durham, Sec'y and Treas. ....	100.00
Advertising commissions .....	113.58
Refunds on reprints, etc. ....	8.10
Miscellaneous expenses .....	12.18
Exchange and collection charges .....	11.00
<b>Total expenses . . . . .</b>	<b>3,726.25</b>
<b>EXCESS OF RECEIPTS OVER EXPENSES .....</b>	<b>\$ 707.46</b>
<b>Add:</b>	
Cash in bank June 1, 1925 .....	2,462.25
<b>Total . . . . .</b>	<b>\$ 3,169.71</b>
<b>Disbursements for Purchase of Capital Assets</b>	
Benefit Building and Loan Ass'n of K. C. 12 shares at \$250 per share \$	3,000.00
Petty cash Imprest fund for Mr. Ferrari .....	100.00
Addressograph cabinet .....	19.00
Filing cases .....	48.11
<b>Total capital expenditures .....</b>	<b>3,162.11</b>
Cash in bank May 28, 1926 .....	\$ 7.60

Moved and seconded that report of secretary-treasurer be accepted, carried.

Report of managing editor C. G. Ferrari was read by C. H. Bailey.

### Report of the Managing Editor

By CHARLES G. FERRARI

The report of the secretary-treasurer includes the financial data for the journal and will not be included again here. Some additional statistical information is added in this report.

At the last convention, in June, 1925, it was reported that the mailing list was 436. It is now 615, an increase of 41 per cent. It is of interest to see where the increase has occurred. Membership data indicate an increase in domestic membership from 184 to 237—approximately 30 per cent. Foreign membership increased from 23 to 27. Corporation membership has decreased from 36 to 34 in spite of new additions to the list. Since the revenue from corporation membership goes into the journal fund, it appears feasible to make this department defray a more substantial fraction of the journal expense, provided that the corporation membership list were several times as large as it is now.

Concerning the subscription data, domestic subscribers have increased in number from 118 to 150—approximately 27 per cent. Foreign subscriptions show the greatest increase, having risen from 72 to 134—an increase of 86 per cent. Last year our journal went to 15 foreign countries. Now it reaches 25. Domestic and foreign subscriptions are almost equal in number. It is to be noted that a large proportion of all new subscribers purchase the back issues of the journal and these are rapidly becoming exhausted.

As a matter of service for the benefit of members and subscribers, arrangements have been made with a reputable book binder to have our journals bound at moderate cost. A sample copy of the bound volumes is on exhibition at the convention. Volumes I and II bound together make an attractive book of convenient size which will be appreciated by those

who have occasion to refer to the journal frequently. An advertisement of the binding company appears in the pages of our journal, and one may deal directly with them, or through the office of the managing editor, who will handle the transaction if preferred. The managing editor will soon have a supply of bound volumes, and those desiring to purchase back issues in this form can be accommodated.

Moved that report be accepted. Seconded, carried.

#### Reports of Committees

Report of auditing committee, by R. M. Bohn. Mr. Bohn reports that books and records of secretary and treasurer were found to be in first-class shape. The industry and efficiency of the secretary-treasurer were commended.

Moved that report be accepted. Seconded, carried.

Report of allied associations committee by H. E. Weaver. Mr. Weaver reports that no regular meeting has been held this year by the entire allied associations committee. Members of this committee, however, were present at nearly all conventions of allied associations.

Moved that report be accepted. Seconded, carried.

Report of committee on employment by C. B. Morison. Mr. Morison reports he has about forty applicants for positions and has been able to secure employment for seven. Suggests that effort be made to stop derogatory comment by chemists who leave the profession.

Moved that report be accepted. Seconded, carried.

Report of publicity committee, by L. R. Olsen.

Mr. Olsen reports that publication material is being sent to seven milling and five baking journals. This material is in most cases greatly appreciated. Moved and seconded that report be accepted. Carried.

Report of question committee by H. E. Weaver. Mr. Weaver reports that five or six questions have been submitted and answered. Help of committee members was freely given. Suggests that when answers to questions are printed in the News Letter credit be given the one who answers. Moved and seconded that report and recommendations be accepted. Carried.

Report of membership committee, by R. K. Durham. Durham reports that during the year 65 new members have been added to the roll. Sixty are active and associate and 5 are corporation members. Six are foreign members—3 from England, one each from Germany, France, and Canada. Domestic additions are divided by states as follows, New York 11, Minnesota 9, Kansas 7, Missouri 5, Illinois and Washington 4 each, Nebraska 3, Oregon, North Dakota, and Michigan 2 each, and one each for Kentucky, Ohio, Texas, Colorado, Iowa, Virginia, California, Indiana, Montana, and Oklahoma.

It is interesting to note that New York state supplied more new members than any other. It is also gratifying to know that 8 members are in Pacific coast states. This indicates that there is in these coast states an excellent field for future endeavor by the membership committee.

It is recommended that this work be continued another year. While 65 new members have been secured we feel that this is a small percentage of the eligible chemists who are not yet members.

Moved that report be accepted. Seconded, carried.

Report of resolutions committee, by R. C. Sherwood.

#### Resolutions

Whereas, the American Association of Cereal Chemists, in session June 7-11, 1926, at the Shirley-Savoy Hotel, Denver, Colorado, recognizing that the success of this the 12th annual convention is due largely to the efforts of our president, R. J. Clark; our vice-president, Leslie R. Olsen, our secretary, R. K. Durham; the program committee, and the local committee on arrangements, therefore



Be it resolved, that we express the appreciation of the association to Messrs. Clark, Olsen, Durham, Warren, Swanson, King, Coleman, Weaver, Frank, Collatz, Liggitt, Fine, Johnson, and Witter.

Be it further resolved that we express to the management of the Shirley-Savoy Hotel our thanks for the fine accommodations, the efficient service and the whole-hearted spirit with which we were received during the entire convention.

Be it further resolved, that we express our appreciation to the Colorado Mill & Elevator Company for providing laboratory facilities for the use of the baking committee; to the Merchants Biscuit Company and the Coors Porcelain Company for the interesting and instructive visits to their plants; to the Denver Fire Clay Company for the use of the lantern and assistance of the operator during the convention; and to the allied firms who so generously aided in providing entertainment.

Be it further resolved, that we extend our most cordial greetings to the Association of Operative Millers, the Millers' National Federation, the American Bakers Association, and the American Association of Bakery Engineers, and express to them our sincere desire to co-operate with them in all matters pertaining to the general welfare and advancement of our common interests.

Be it further resolved, that our thanks be extended to Mr. F. C. Bell and his associates of the Omaha Grain Exchange for the entertainment afforded the northwest members en route to the convention.

Be it also resolved, that we express in this truly inadequate manner our most sincere appreciation of the work of the editors of Cereal Chemistry, Dr. C. H. Bailey, Miss Alice McFeely, and Mr. C. G. Ferrari, and our thanks to them for the service they have so efficiently rendered in building and maintaining the present high standard of Cereal Chemistry as a scientific journal.

Be it also resolved, that this association, being cognizant of the tireless efforts and long-continued studies of Mr. Harry Snyder in ascertaining the facts underlying the moisture factor in wheat flour, express to Mr. Snyder its appreciation of his years of service in the advancement of cereal chemistry.

Be it also resolved, that our secretary be instructed to spread these resolutions upon the minutes of this convention and to forward copies of the resolutions to those mentioned therein.

Resolutions Committee,

R. C. Sherwood, Chairman,  
A. A. Schaal,  
C. B. Kress.

Moved that resolutions be adopted. Seconded, carried.

Report of nominations committee, by R. W. Mitchell.

Moved that convention be recessed for ten minutes for caucus.

Seconded, carried.

Recess called at 10:00 a. m.

Meeting called to order at 10:15 a. m. by President Clark.

The following nominations were reported by nominations committee:

President, R. J. Clark, C. B. Kress, L. D. Whiting.

Vice-President, L. R. Olsen, M. D. Mize, R. C. Sherwood.

Secretary-Treasurer, R. K. Durham, R. M. Bohn, A. E. Curtis.

Editor-in-Chief, C. H. Bailey, Raymond Hertwig, C. B. Morison.

Managing-Editor, C. G. Ferrari, Julius Hendel, A. D. Wilhoit.

Moved that rules be suspended and the convention unanimously elect Clark, Olsen, Durham, Bailey, and Ferrari.

Motion withdrawn.

The following officers were elected.

President R. J. Clark

Vice-Pres. L. R. Olsen

Sec'y-Treas. R. K. Durham

Editor-in-Chief, C. H. Bailey

Managing-Editor, C. G. Ferrari.

Moved that the secretary send telegram to Mr. Ferrari notifying him of his re-election to office of managing-editor. Seconded, carried.

New business:

Moved by Weaver that it be put on record as the sentiment of this body that the two officers, president and vice-president be rotated, beginning at next election and that term of office be one year. Seconded, carried.

Moved by Mangels that the association suggest that the executive committee draft an amendment to the constitution making election rules more flexible.

Motion withdrawn.

Moved by Kress that Article 3, Section 1, shall be amended by striking out the last word "sustaining" and substituting therefor the word "corporation." Seconded, carried.

Moved as an amendment to the constitution that Article 3, Section 6, shall be made Article 3, Sec. 7, and Article 3, Sec. 6 shall be then inserted to read as follows: Corporations that are interested in or concerned with the use of cereals or cereal products may become corporation members upon application to the secretary-treasurer, and be granted all privileges of the association except the voting power. Seconded, carried.

Moved that constitution be amended as follows: Article 5, Section 2 shall be amended to read "the annual dues of active and associate members of this association, etc."

Moved that the editors of the Journal are empowered to increase the subscription rate to non-members when the size of the Journal and its business relations justify such increase. Seconded, carried.

Moved that corporation membership dues shall be \$10 per annum payable in advance, and said fees shall be diverted to the publications fund. Seconded, carried.

Moved that the executive committee be made up of two ex-presidents and one other member so that association policies may be made more permanent. Seconded, carried.

Moved that charters be granted the various local cereal clubs and that they be made sections of the A. A. C. C. provided that all the club officers and at least 75 per cent of the club members are also association members. Seconded, carried.

Moved that the methods committee be empowered to revise and publish a new book of methods. Seconded, carried.

Moved that gold medals be offered by the association for the best papers presented at its annual convention, one medal for the best paper on the industrial application of cereal chemistry and one for the best paper on fundamental research in cereal chemistry. Seconded, lost.

Moved that this matter be referred back to the executive committee to be revised and the committee be empowered to act. Seconded, carried.

Moved that the duties of each committee be outlined as seen by the committee chairman and this material collected into a condensed form which, in time, might serve as a guide book. Seconded, carried.

Moved by Lawellin that this association elect as an honorary member Mr. M. F. Dillon, Secretary of the A. O. M. in recognition of his many services to this association, particularly in our past joint conventions. Seconded, carried.

Moved that the Constitution be amended as follows: That Article 6, Section 1, be amended to read "meeting shall be held annually at a place to be designated at the annual business session by convention vote and at such time as shall be determined by the executive committee." Seconded, lost.

Meeting adjourned at 12:00 noon.

Friday, June 11

Meeting called to order at 8:45 a. m. at Shirley-Savoy Hotel by President Clark.

Appointment of Committees.

Executive Committee, L. R. Olsen, Chairman, H. E. Weaver, R. W. Mitchell, M. A. Gray.

Committee on Allied Associations: H. E. Weaver, Chairman, L. R. Olsen.

Committee on Methods of Analysis: D. A. Coleman, Chairman, F. A. Collatz, H. E. Weaver, M. D. Mize, C. B. Morison, H. C. Fellows.

Committee on Standardization of Laboratory Baking: M. J. Blish, Chairman, C. B. Morison, R. S. Herman, L. H. Bailey, Alice M. Child, R. C. Sherwood, E. E. Werner, L. D. Whiting.

Committee on Employment: C. B. Morison, Chairman.

Publicity Committee: L. R. Olsen, Chairman, A. A. Towner, R. C. Sherwood, S. J. Lawellin.

Question Committee: H. E. Weaver, Chairman, C. G. Harrel, L. D. Whiting, L. H. Bailey, A. W. Alcock.

Membership Committee: R. K. Durham, Chairman, O. W. Walker, L. D. Whiting, T. E. Carl.

Program Committee: C. O. Swanson, Chairman.

Paper—"Ash Determination," by Mr. Brendel and Mr. Shirk.

Paper—"Comparison of the Official Method of Ashing Plant Tissues and Products with the Hertwig and Baily Method," Charles F. Rogers.

Paper—"Plasticity—Its Possibilities in Cereal Research," by J. A. Dunn.

Paper—"Variation in Diastatic Activity of Wheat Flour Due to Variety and Climate," by C. E. Mangels.

Paper—"Moisture in Flour—a Review of Recent Work," by C. B. Morison.

Paper—"Critical Periods for Moisture in the Development of the Wheat Crop," by D. W. Robertson.

Paper—"Effect of Application of Moisture at Different Periods on the Nitrogen Content of Wheat," by Alvin Kezer.

Paper—"Factors Influencing the Viscosity of Flour-Water Suspensions," by Arnold Johnson.

Paper—"Milling and Baking Tests on Garnet Wheat," by R. C. Sherwood.

Moved that the association extend thanks to the Denver Fire Clay Company for use of lantern, screen, etc. Seconded, carried.

Moved by Blish that the secretary-treasurer be presented with \$100 for work done the last year. Seconded.

Moved as an amendment that the amount be doubled. Seconded, carried.

Original motion carried.

Moved that a vote of thanks be extended to L. A. Fitz for his splendid work on the baking committee. Seconded, carried.

Meeting adjourned at 11:20 a. m.

Meeting called to order at 1:15 p. m. by President Clark.

Talks on laboratory management by H. E. Weaver, R. S. Herman, M. A. Gray, L. R. Olsen, and others.

Talk on status of the cereal chemists, by R. J. Clark.

Moved that convention be adjourned. Seconded, carried.

Convention adjourned at 3:05 p. m.

Registration American Association of Cereal Chemists Convention, Denver, Colorado

June 7-11, 1926

J. C. Wood Scott County Milling Co., Sikeston, Mo.

H. J. Fleming, Nebraska Consolidated Flour Mills, Omaha, Neb.

R. K. Durham, Rodney Milling Co., Kansas City, Mo.

S. J. Lawellin, Wallace-Tiernan Co., Newark, N. J.

H. D. Liggett Jr., Colorado Milling & Elevator Co., Denver, Colo.

R. J. Clark, Goerz Flour Mills Co., Newton, Kansas



- E. J. Sisser, Commander Mills, Minneapolis, Minn.  
R. M. Bohn, c/o W. E. Long Co., Chicago, Ill.  
A. E. Curtis, Midland Flour Mills, Kansas City, Mo.  
T. G. Fletcher, Wichita Mill & Elevator Co., Wichita Falls, Texas  
C. E. Mangels, No. Dak. Experiment Station, Agr. College, N. Dak.  
L. R. Olsen, International Milling Co., Minneapolis, Minn.  
Paul Larson, Grain Exchange, Sioux City, Iowa.  
M. D. Mize, Omaha Grain Exchange, Omaha, Neb.  
O. W. Walker, Wasco Warehouse Milling Co., The Dalles, Ore.  
C. H. Bailey, University of Minn., University Farm, St. Paul, Minn.  
J. A. Dunn, Pillsbury Flour Mills, Minneapolis, Minn.  
Julius Hendel, Cargill Elevator, Minneapolis, Minn.  
H. H. Johnson, Gooch Mill & Elevator Co., Lincoln, Neb.  
E. J. Rosse, Maney Milling Co., Omaha, Neb.  
L. A. Scanland, Minn. State Lab., Duluth, Minn.  
G. A. Ramsdell, Board of Trade, Superior, Wis.  
J. P. Lewis, Montana State Grain Inspection Dept. Bozeman, Mont.  
C. W. Ingman, Minn. State Lab., Minneapolis, Minn.  
C. E. Erb, St. Joseph Testing Lab., St. Joseph, Mo.  
R. C. Sherwood, State Testing Mill, Minneapolis, Minn.  
F. L. Dunlap, Industrial Appliance Co., Chicago, Ill.  
A. W. Alcock, Western Canada Flour Mills Co., Winnipeg, Can.  
Paul Logue, Provident Chemical Works, St. Louis, Mo.  
V. T. Hooft, Novadel Process, Buffalo, N. Y.  
T. J. Harrison, Manitoba Agricultural College, Winnipeg, Can.  
R. L. Frye, Kansas Flour Mills Co., Kansas City, Mo.  
V. E. Fisher, Standard-Tilton Milling Co., Alton, Ill.  
I. Quimby, Victor Chemical Works, Chicago, Ill.  
C. B. Kress, Sperry Flour Co., Vallejo, Calif.  
H. L. Lentz, Robinson Flour Mills, Salina, Kans.  
H. L. Thompson, Crete Flour Mills, Crete, Neb.  
A. D. Wilhoit, Wilhoit Laboratories, Minneapolis, Minn.  
R. W. Mitchell, American Bakery Materials Co., Menominee, Wis.  
M. J. Blish, Nebraska Experiment Station, Lincoln, Neb.  
W. L. Bergman, Industrial Appliance Co., Chicago, Ill.  
Francis Hruska, Prague, Czechoslovakia.  
Arnold Johnson, Agricultural Experimental Station, Bozeman, Mont.  
E. F. Olmstead, Great West Mill & Elev. Co., Amarillo, Texas.  
W. F. Johnson, Willard F. Johnson Co., Denver, Colo.  
I. L. Fine, Colorado Milling & Elevator Co., Denver, Colo.  
C. T. Newell, Burrus Mill & Elevator Co., Ft. Worth, Texas  
Claude F. Davis, Western Star Flour Mills, Salina, Kans.  
J. S. Schlesinger, H. D. Lee Flour Mills, Salina, Kans.  
Ralph Herman, Ismert-Hincke Milling Co., Kansas City, Mo.  
F. C. Witter, Colorado Milling & Elevator Co., Denver, Colo.  
F. A. Collatz, Washburn-Crosby Co., Minneapolis, Minn.  
L. D. Whiting, Ballard & Ballard, Louisville, Ky.  
E. E. Werner, Miller's National Federation, Washington, D. C.  
L. H. Fitz, U. S. Dept. of Agr., Postal Bldg., Chicago, Ill.  
E. F. Tibbling, Washburn-Crosby Co., Kansas City, Mo.  
C. B. Morison, American Institute of Baking, Chicago, Ill.  
W. Siedhoff, E. E. Werner Laboratory, St. Louis, Mo.  
T. R. James, Sperry Flour Co., Spokane, Wash.  
A. A. Schaal, Biscuit & Cracker Mfr's Assn., Dunwoody, Institute, Minneapolis, Minn.  
C. F. Rogers, Colo. Agricultural College, Ft. Collins, Colo.  
Raymond Hertwig, The Hecker-H-O Co., Buffalo, N. Y.  
M. A. Gray, Pillsbury Flour Mills Co., Minneapolis, Minn.  
L. H. Bailey, Bureau of Chemistry, Washington, D. C.  
R. B. Potts, Wichita Flour Mills Co., Wichita, Kans.  
A. A. Towner, Red Star Flour Mills, Wichita, Kans.  
L. E. Leatherock, Kansas Milling Co., Wichita, Kans.  
W. H. Carter, American Maid Flour Mills, Houston, Texas  
D. E. A. Rogers, Longmont Farmers Milling & Elevator Co., Denver, Colo.  
D. A. Coleman, U. S. Dept. of Agr., Washington, D. C.  
Oscar Skovholt, Cascade Milling & Elevator Co., Cascade, Mont.  
D. W. Robertson, Colorado Agricultural College, Ft. Collins, Colo.  
M. C. Ross, Lindsborg Mill & Elevator Co., Lindsborg, Kans.  
W. E. Stokes, Royal Baking Powder Co., New York  
C. J. Patterson, C. J. Patterson Corp., Kansas City, Mo.  
H. E. Weaver, Larabee Flour Mills, St. Joseph, Mo.  
Paul S. Nice, Chemist and Bacteriologist, Denver, Colo.  
Mr. Alexander, Northwestern Miller, Denver, Colo.  
Alvin Kezer, Agr. Experiment Station, Fort Collins, Colo.